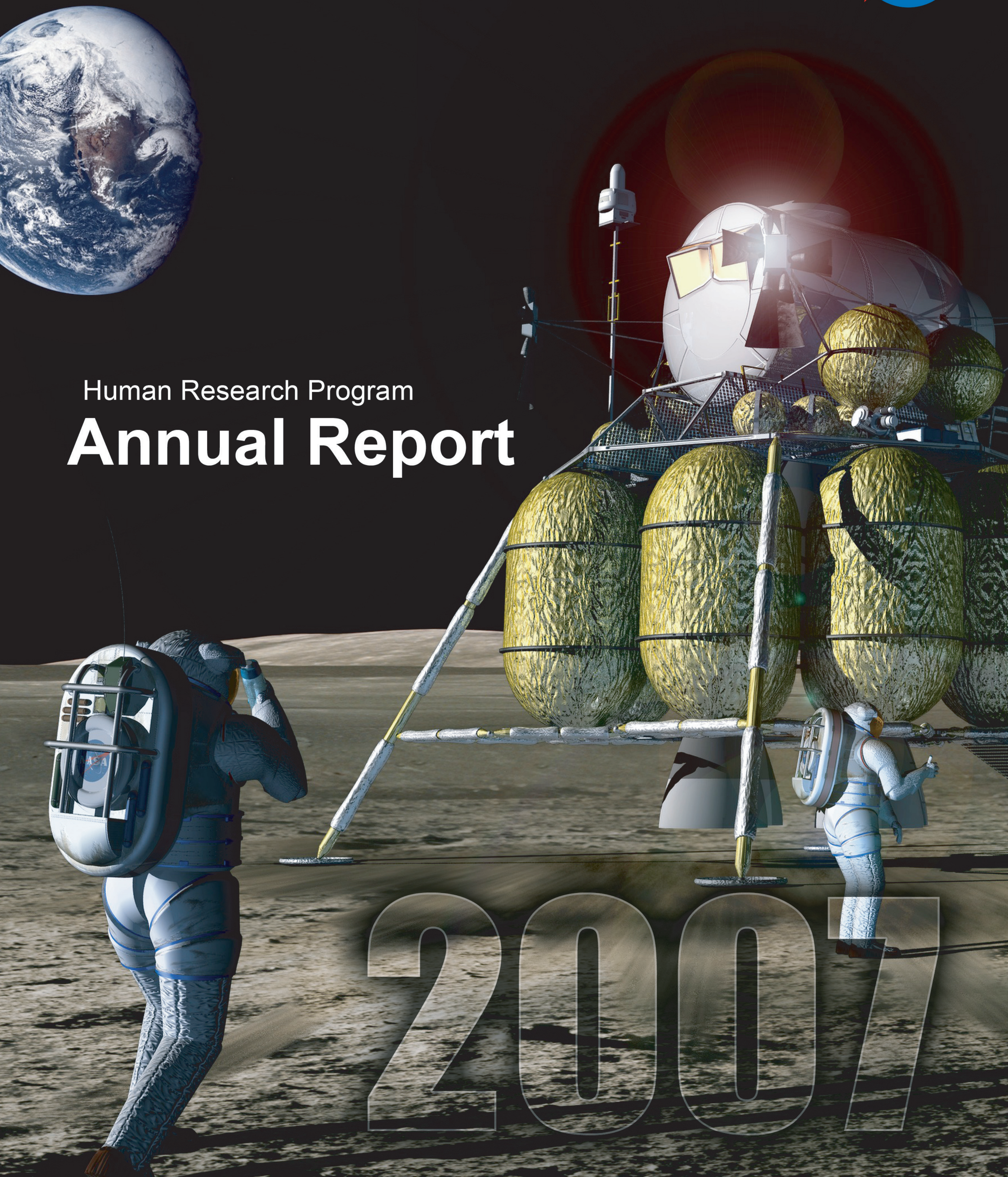
National Aeronautics and Space Administration

Human Research Program

Annual Report

2007



Cover: NASA's Constellation Program is getting to work on the new spacecraft that will return humans to the Moon and blaze a trail to Mars and beyond. This artist's rendering represents a concept of a lunar lander and astronauts on the Moon's surface. Earth is also visible in this rendering.

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Message from the Program Manager

I take great pride in delivering this Annual Report of NASA's Human Research Program (HRP). This report is a visible record of team performance driven by a shared value of personal and professional excellence. These values are shared by the scientists who gain knowledge, science managers who forge the directions of the applied research, project managers who balance resources and strive for productivity and efficiency, and the technical staff who each bring their own brand of technical and professional excellence to their job every day.

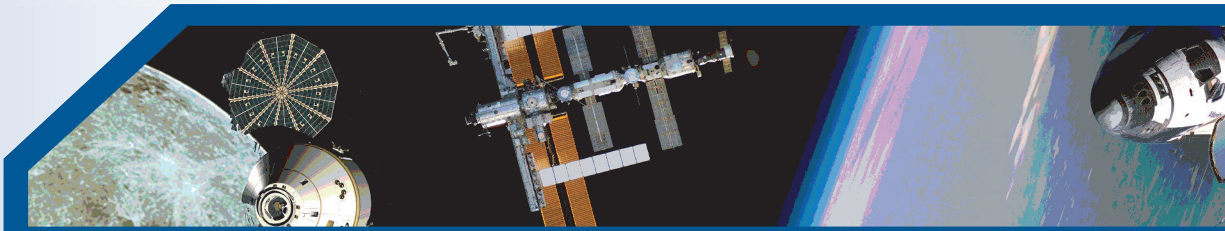
This agency has embarked on a renewed course of human exploration of the Moon and the inner solar system. As with the first human space exploration program, a defined timetable forces NASA's research programs to focus on the tasks that enable safe human exploration and the research tasks that make it productive. This "mission driven" mandate is expressed clearly in the goals and objectives of the HRP. The technical challenges of designing spacecraft, habitats, and mobility systems and then conducting missions on the lunar surface for 6-month intervals will depend upon the knowledge and technological solutions delivered by this program.

The HRP has made tremendous strides over the past year by creating a management foundation that keeps the program focused on the outcome of each piece of research and technology and how it benefits the human exploration enterprise. As a team, we have created a well defined set of risks and analyzed the gaps in technology needed to be filled. We have laid out the research activities on a timetable considering the availability of known assets and resources. The most recent triumph in this area was the release of the Integrated Research Plan in December 2007. The availability of this long-range plan makes clear the approach and expected products of HRP applied research and technology.

The program has been structured to enlist the best minds on earth to help us with this challenge. NASA and the National Space Biomedical Research Institute have issued their first joint solicitations on Space Radiation and Multidiscipline Research focused on the program's needs and technology gaps. And there has been significant work internationally aimed at a greater sharing of data and leveraging of flight and ground research.

In the coming years, the Human Research Program expects to build on this strong foundation and make human exploration crews as safe, healthy, and productive as possible. Along the way, we will seek out the added benefits that science and technologies bring to the American public and all people.

Dennis J. Grounds
Program Manager



Background

The Human Research Program (HRP) is critical to NASA and its implementation of the Vision for Space Exploration. The science and technology development activities within the HRP are integral to the long-term goal of building an outpost on the Moon and preparing humans for future space exploration. The HRP implementation strategy utilizes a balance of laboratory, flight, and ground analogs to understand the impact of the space exploration environment on the human system. For example, the HRP uses the International Space Station to perform research and to test and verify equipment and procedures in the spaceflight environment. The HRP is defining the challenges that humans will face during exploration missions and is working to mitigate the risks associated with these challenges.

The Human Research Program has been in existence for 2 years. During the inaugural year, the management and technical staff formulated a program to ensure relevancy and connectivity to the exploration mission. Each element of the program and the supporting offices are designed and chartered to accomplish the goals of the HRP, enumerated below. The program continued requirement alignment during the second year, further evolving the links from risks to gaps and activities to products. The HRP further aligned activities with the most important gaps in knowledge to address the immediate needs of the Constellation Program.

Goals and Objectives

The goal of the HRP is *to provide human health and performance countermeasures, knowledge, technologies, and tools to enable safe, reliable, and productive human space exploration.* The HRP objectives are to

1. Develop capabilities, necessary countermeasures, and technologies in support of human space exploration, focusing on mitigating the highest risks to crew health and performance

2. Sponsor research and technology development that enables modification or development of human spaceflight medical, environmental, and human factors standards

3. Develop technologies that serve to reduce medical and environmental risks, to reduce human-systems resource requirements (e.g., mass, volume, power, data), and to ensure effective human-system integration across exploration systems

4. Ensure maintenance of Agency core competencies necessary to enable risk reduction in the following areas:
   a. Space medicine
   b. Physiological and psychological effects of long-duration spaceflight on the human body and behavior
   c. Space environmental effects, including radiation, on human health and performance
   d. Space human factors

When NASA streamlined its organizational structure to implement the Vision for Space Exploration, the restructured organization included mission directorates with clear organizational roles and responsibilities. The HRP resides within the Exploration Systems Mission Directorate and focuses on investigating and mitigating the highest risks to human health and performance in support of NASA's exploration missions. Figure 1 shows the organizational structure of the directorate, including the Human Research Program.

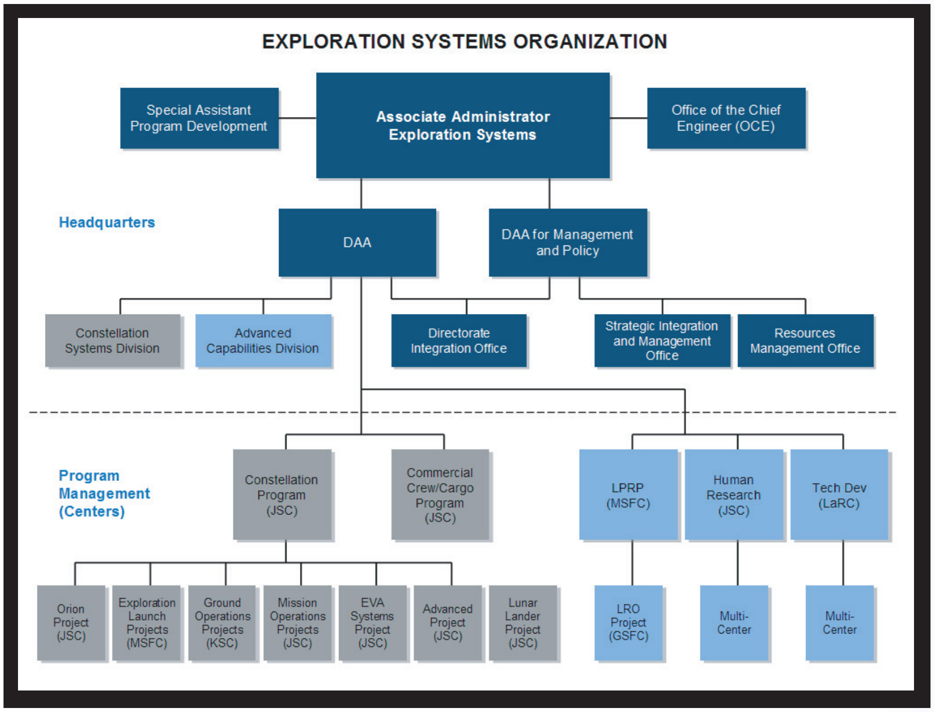


Figure 1. Exploration Systems Mission Directorate Organization

The organization of the HRP is designed to support and accomplish the goals of the Exploration Systems Mission Directorate. The six elements, seen in Figure 2, that comprise the HRP are defined and focused to accomplish specific goals. These elements are the International Space Station Medical Project, Space Radiation, Human Health Countermeasures, Exploration Medical Capability, Behavioral Health and Performance, and Space Human Factors and Habitability.

Two offices support program management and provide integration across the elements. The Science Management Office maintains scientific integrity of the HRP research, reviews and integrates science activities across the HRP elements, reviews the prioritization and implementation of flight and ground analog activities, communicates research needs to other programs within NASA (e.g., the Constellation Program), and cultivates strategic research partnerships with other domestic and international agencies. The Program Integration Office provides program planning, integration, and coordination across the program. This office ensures close coordination of exploration customer needs and HRP deliverables to meet those needs.

The management of the program is at the Johnson Space Center with expertise from the Ames Research Center, Glenn Research Center, Kennedy Space Center, and Langley Research Center. With a OneNASA approach, the numerous NASA centers provide core competencies and additional research capabilities to meet program goals. For example, the Space Radiation effort includes work performed at the Johnson Space Center and the Langley and Ames Research Centers. The Behavioral Health and Performance and Space Human Factors and Habitability teams are from the Johnson Space Center and Ames Research Center. The Exploration Medical Capability effort and the Human Health Countermeasures work are performed at the Johnson Space Center and the Glenn and Ames Research Centers. The Kennedy Space Center and the Ames Research Center support the International Space Station (ISS) Medical Project with baseline data collection, launch and landing support, and international experiment coordination.

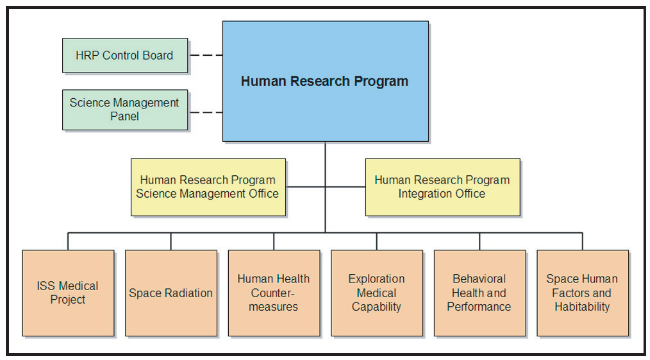


Figure 2. HRP Organization Chart

Partnerships

The HRP relies on numerous partnerships to provide human health and performance countermeasures, knowledge, technologies, and tools to enable safe, reliable, and productive human space exploration. The NSBRI is a partner with the HRP to investigate both the physical and psychological challenges of long-duration human spaceflight. A research consortium, the Institute develops countermeasures and technologies that ensure safe and productive human spaceflight. The Institute bridges research, technical, and clinical expertise of the biomedical community with the scientific, engineering, and operational expertise of NASA. The focus is on operationally relevant outcomes that support NASA's Vision for Space Exploration.

The HRP also maintains collaborative relationships with the International Partners through various working groups. These relationships enhance the research capabilities and provide synergism between the research efforts among countries. Additional information about the program can be found at: **http://humanresearch.jsc.nasa.gov**.

HRP partnerships and collaborations (examples)	Benefits
National Space Biomedical Research Institute	Leverages off prestigious research institutions to address human health
Universities Space Research Association	Capabilities of the university community and other sources of knowledge transfer
International Space Life Sciences Working Group with members from Canada, Japan, Germany, Ukraine, France, and the European Space Agency	Optimized collaborative research with ground analogs
Joint Working Group with Russia	Synergy in research and operations, optimal use of the ISS
National Institutes of Health (NIH), the Department of Energy, the Centers for Disease Control and Prevention, the Department of Agriculture, and the Department of Defense	State-of-the-art research facilities and research activities and technology development of mutual interest
Cleveland Clinic	Human health countermeasures expertise
National Underwater Research Center (NURC), National Oceanic and Atmospheric Administration (NOAA), National Science Foundation (NSF) Antarctic expeditions and Devon Island	Aquarius Habitat (NASA Extreme Environment Mission Operations [NEEMO] operated by the University of North Carolina) and other analog environments such as Antarctica and Devon Island
University of Texas Medical Branch in Galveston	Access to NIH GCRC capabilities for flight analog/bedrest capabilities
Brookhaven National Laboratory	State-of-the-art facility to perform radiobiology and physics experiments
Loma Linda University	Space radiation research and facilities

Examples of partnerships and collaborative relationships with universities, industries, and government agencies

Science Management Office

The critical function of the Science Management Office (SMO) is to maintain scientific integrity. The office manages the review and selection of science in accordance with NASA policies. The Program Scientist coordinates science management reviews and manages the Program's peer review process. The office continues to maintain the focus on exploration and align the science portfolio to support human exploration of the solar system.

The SMO oversees the top, program-level planning and coordination of research and the development of technology in its early phases. The office ensures that research objectives and findings are integrated across the diverse research elements that comprise the HRP. In addition, the SMO works with domestic agencies and international partners to develop programs that complement each other. The office identifies and cultivates strategic partnerships. These partnerships provide the Human Research Program with state of the art facilities and renowned experts to focus on the highest risks to astronaut health and performance in support of exploration missions. Additional information about this office can be found at: **http://humanresearch.jsc.nasa.gov/elements/smo.asp**.

Major Accomplishments

NASA, in partnership with the National Space Biomedical Research Institute (NSBRI), released a research announcement entitled, "*Research and Technology Development to Support Crew Health and Performance in Space Exploration Missions*." NASA solicited proposals in the areas of bone, cardiovascular, muscle, nutrition, and lunar analog bed rest investigations. The NSBRI solicited proposals in the areas of bone loss; cardiovascular alterations; human performance factors, sleep, and chronobiology; muscle alterations and atrophy; neurobehavioral and psychosocial factors; nutrition, physical fitness and rehabilitation; sensorimotor adaptation; smart medical systems; and technology development. Awards occur in May 2008.

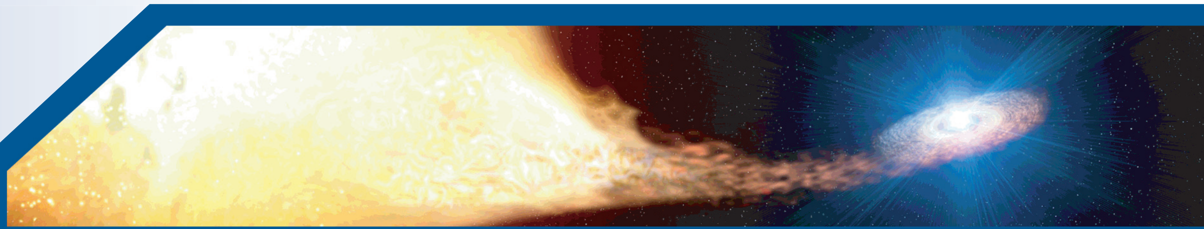
The Science Management Plan received final signature and approvals in February 2007. This document describes the policies and processes used to manage science within the HRP. In accordance with sound management practices, the Science Management Plan provides the critically important linkage between the Agency's goals and the research projects that are instrumental in achieving them.

HRP Investigator's Workshop

The Human Research Program sponsored the 2007 Investigator's Workshop at South Shore Harbor in League City, Texas. The 340 attendees included NASA, the NSBRI, and extramural investigators holding grants from the program. Presenters reported on their current research status and significant results.

The office completed the International Space Station sample return analysis to assess the impact and alternatives after the Shuttle is no longer available. This included:

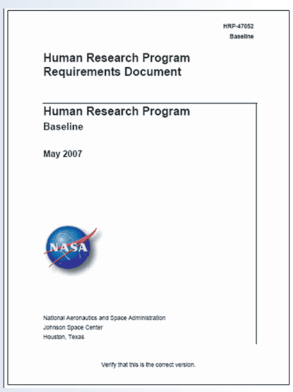
- Transportation survey to examine methods for delivering equipment and supplies to the International Space Station and returning samples to Earth
- Measurement survey to identify test results needed by the HRP and examine alternative methods of obtaining those measurements, including hardware development for on-orbit laboratory analyses
- Sample return decision package to consider the implications of implementing several distinct strategies for solving the sample return problem from the station
- Technology development proposal to develop an implementation strategy for one of the strategies described in the sample return decision package



Program Integration Office

The Program Integration Office (PIO) is responsible for program planning, integration, and coordination. The office ensures close coordination of exploration customer needs and program deliverables to meet those needs. To ensure quality and consistency across all processes, the PIO maintains all programmatic documentation. In addition, the office manages grants and assesses the integrated programmatic risks, reporting results to the HRP Manager.

Major Accomplishments



HRP-47052
Baseline

Human Research Program
Requirements Document

Human Research Program
Baseline

May 2007

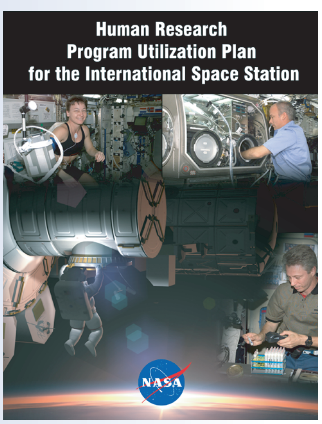
National Aeronautics and Space Administration
Johnson Space Center
Houston, Texas

Verify that this is the correct version.

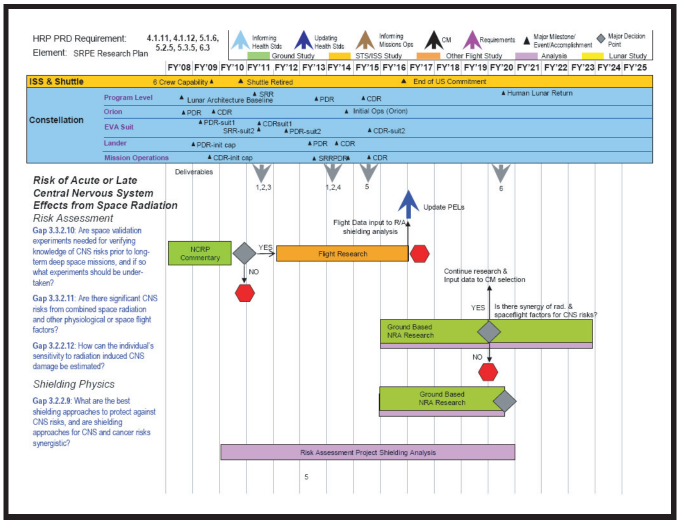
HRP Program Requirements Document

During 2007, this office continued requirement alignment by baselining a number of critical program-level documents, such as the HRP Requirements Document and the Integrated Master Schedule.

The office led a significant study requested by the NASA Strategic Management Council to identify how the HRP planned to use the International Space Station to support exploration missions. That assessment is further discussed in the Major HRP Technical Accomplishments section of this document.



The most significant accomplishment for the office was baselining the HRP Integrated Research Plan, a comprehensive document that pulls together the program's overall plan to address human health risks. This plan defines the research and technology required over the next 15 to 20 years. The plan includes the risk to astronaut health, the operational relevance of the risk to exploration missions, the risk priority, the gaps in current knowledge with a brief description for each, and the activity or activities necessary to address the gap. For each activity, the resulting product/deliverable, delivery milestone, and the required platform are defined. The Integrated Research Plan was derived directly from the HRP Requirements Document with detailed activities and schedule milestones provided by each Element. The Integrated Research Plan is and will be a key management tool for resource allocation across the program and product delivery to stakeholders.



HRP Integrated Research Plan (schedule example)

Major Program Technical Accomplishments

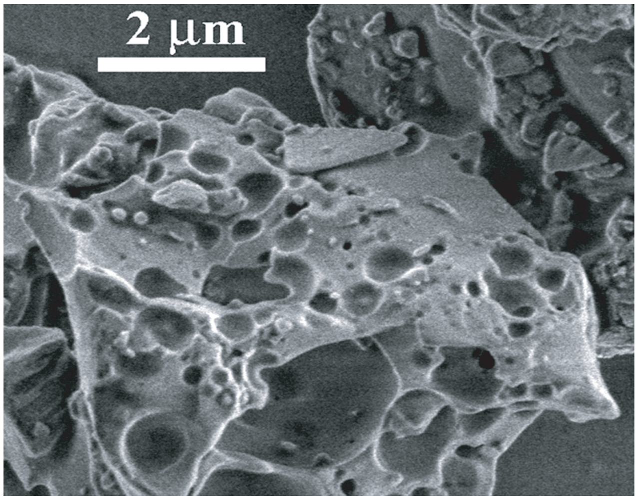
During 2007, the HRP had several significant accomplishments that have far reaching implications for human exploration. These major accomplishments are briefly described below, with more detail provided within the Program Element responsible for the work.

Lunar Dust

During the Apollo missions NASA found that lunar dust was pervasive and it not only stuck tenaciously to astronaut's clothing and shoes, it was abrasive. There are two reasons that lunar dust clings to surfaces. The particles are sharp, irregular shapes that formed by meteorite strikes over millions of years that melted the lunar dust into glass-like rocks then broke them into powdered glass fragments. Unlike dust on Earth, which is formed by wind and water erosion and is constantly smoothed by friction, lunar dust remains coarse and jagged. The jagged edges of these particles act like microscopic burrs that attach themselves to surfaces. Secondly, the dust has an electrostatic charge, much like the charge we get if we rub a balloon on our hair or walk across the carpet wearing socks. The unshielded ultraviolet rays and charged solar wind from the sun give the surface of lunar dust particles a charge. This charge also causes the dust particles to stick to all surfaces with which they make contact, similar to the way our hair sticks to the balloon.

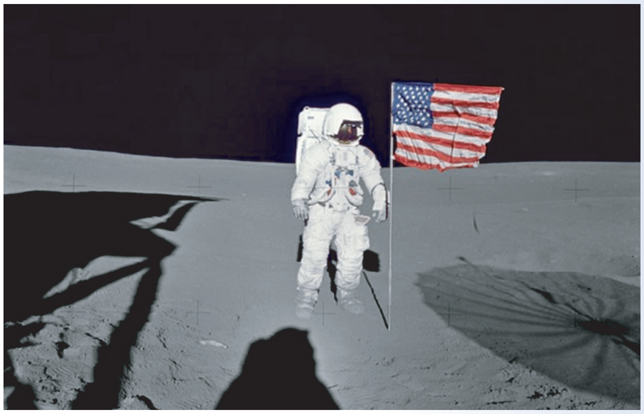
Astronaut Eugene A. Cernan, Apollo 17 commander, inside the lunar module following EVA-2 covered in lunar dust

These characteristics make lunar dust harmful to equipment and space suits. It poses challenges to designers of the airlock, filtration systems, and monitoring systems. Of great concern to the HRP; however, is the effect on astronaut health. Astronauts will bring the dust into vehicles and habitats where it can be inhaled. If inhaled, the dust particles can deposit deep in the lungs and may be difficult to cough up. If the surfaces of the dust grains are as reactive as some have postulated, then the first cells to encounter the grains may suffer unusual damage. On Earth, some materials of similar size and characteristics to lunar dust are considered serious hazards to human health (e.g., quartz dust), especially if they are freshly fractured. Studies of lunar dust show that a substantial portion of lunar dust is in the respirable range. Roughly 10% is less than 10µm in size.



A substantial portion of lunar dust is in the respirable range and has an extremely high surface area (8 times that of a sphere of same external size).

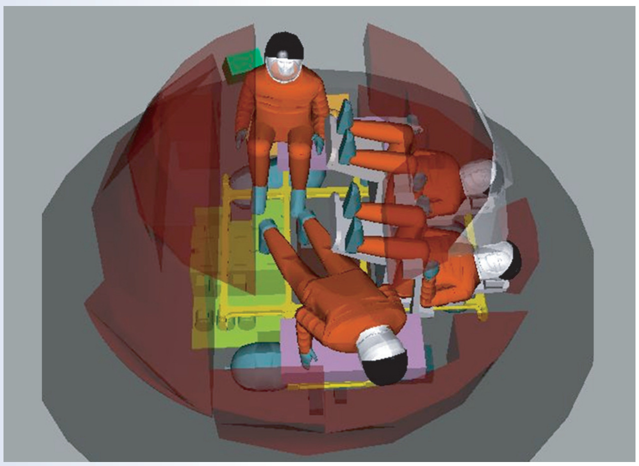
The HRP has a number of efforts in work to understand the risks to human health and set a human exposure standard that protects astronaut health to an acceptable level of risk without being overly conservative. The goal is to have standards identified by 2010 in time to influence the design of lunar surface systems. Advanced Environmental Health Project researchers are using Apollo operational experiences and forensic engineering of the Apollo systems to understand the magnitude of the dust problem. The particle size distribution of the dust retained in the Apollo suits has shown that most of the dust grains are in the respirable range. Other investigators are working to develop high-fidelity simulants that contain nano-iron in an effort to more closely mimic authentic lunar dust. In 2007, researchers tested samples of quartz, lunar dust simulant, and authentic lunar dust under conditions where each dust was activated and not activated by grinding. They found changes in fluorescence indicating that hydroxyl radical production increases most with activation of authentic lunar dust and least with quartz. Toxicologists have completed pilot studies of the cellular and biochemical responses of mouse lungs to various dusts, including authentic lunar dust, after intrachael instillation. These studies have shown that lunar dust elicits a strong cellular response.



Astronaut Edgar Mitchell, lunar module pilot for the Apollo 14, by the U.S. flag with lunar dust on his suit

Human Anthropometric Modeling for Spacecraft Design

The Constellation program plans a variety of new vehicles and equipment for exploration of the Moon and Mars. The complex interactions and interfaces between the human and the machine require human factors solutions. To incorporate human factors principles during the early design phase of the Crew Exploration Vehicle, NASA is using human modeling to provide designers with information about the needs of the crewmember end user. To this end, the modeling project was created to advance anthropometric modeling to state-of-the-art for vehicle design and requirements verification. Anthropometric modeling is a cost effective way to refine the interior design of the vehicle, such as the size of the seat, the placement of windows, and the layout of the displays. To physically reconfigure even a low fidelity mock-up is both slow and costly. Results of this modeling project allow designers to easily look at different sizes or sexes of humans, their reach, range of motion, and field of vision.



Seat layout for contingency EVA

To ensure that NASA's model is state of the art and consistent with best practices, the anthropometric modeling project reviewed seven commercial modeling tools and surveyed the best practices in other fields such as automotive. Furthermore, NASA's anthropometric data base, capturing all astronaut candidates interviewed since 1980, provides an excellent source of data on body size and strength. Today's researchers have the use of such tools as a body scanner which captures a whole-body digital image that can be measured and manipulated using software, high-speed cameras to provide body position data in real-time, force transducers to measure force applied by or to people, tools to quantify the effects of space suit design on range of motion and strength, accurate models that predict illumination and glare and determine visibility conditions for space operations, and inclusive visual environments. These capabilities greatly enhance the ability to support design challenges of the Constellation Program.

Reach comparison study using both models and real people

EVA Suit Design

In the design of new extravehicular activity (EVA) space suits for the Constellation Program, understanding the impacts of various designs is critical for astronauts to safely traverse the lunar surface and return to the home port if the lunar rover is unable to function. Design considerations include suit weight, pressure, the inertial mass, and the ease of moving suit joints. These all affect human physiology, particularly the metabolic or energy expenditure needed to work while wearing a space suit.

EVA suit design and walk-back testing

The EVA Physiology, Systems and Performance Project made significant progress during 2007 in understanding the impact of the parameters of EVA suit design on human performance. A suit weight study was completed to assess how suit weight impacts energy requirements during EVAs. The results indicate that weight is much more important for longer translations between exploration sites, where suit weight begins to adversely affect metabolic rate. Additional studies compared results from the 10K walk-back test, which was conducted on a treadmill to a 10K walk-back on a simulated lunar terrain. Studies conducted during the Haughton-Mars Project allowed scientists to look at both metabolic data and information on the actual distance traversed. The Haughton-Mars Project is an international, interdisciplinary field research project carried out near the Haughton impact crater on Canada's northern Devon Island, a landscape considered analogous to the Moon or Mars. In this landscape, participants in the study could not walk between points in a straight line, thus, the actual distance an astronaut must walk to move from one location to another, around rocks and other obstacles, is much longer than the radial distance used in treadmill testing. By measuring the true distance, researchers identified a correction factor that can be used when performing tests in a laboratory environment on a treadmill.

Example of a study on the effects of center of gravity on performance

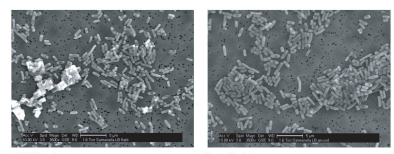
Microbiology and the Food System

NASA sets the microbiological limits for crew exposure to microorganisms very conservatively to minimize the risk of crew exposure to pathogens during a mission. To ensure these requirements are met, NASA has established rigorous monitoring procedures. Potable water and the vehicle's habitable environment are thoroughly monitored prior to flight. In addition, the quarters where the crew is quarantined before flight are also monitored. To reinforce the preflight preventive measures, air, surface, and potable water samples are analyzed periodically aboard the International Space Station.

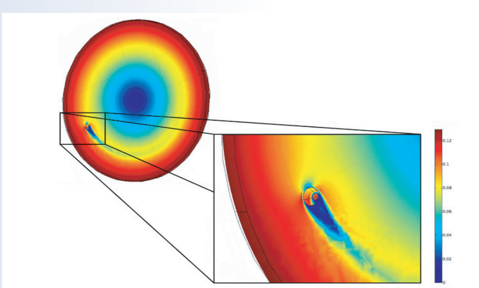
Expedition 16 Commander Peggy Whitson eats a meal in the Service Module, Zvezda

As food is a common carrier of medically significant organisms, NASA has stringent microbial monitoring of both the food preparation area and selected samples from each lot of food that is prepared. Scientists follow strict protocols for food preparation and preflight microbial analysis to minimize the transfer of pathogens to the crew during a mission. Many food items are processed on Earth to prevent microbial growth prior to consumption either through commercial sterilization or through dehydration.

The Advanced Environmental Health Project performs studies on microorganisms to determine if they exhibit unique responses to space flight that may affect infectious disease risk to the crew. Results of studies performed during 2007 showed that the virulence of the food-borne pathogen, *Salmonella*, increased during space flight compared to identical bacterial cultures grown on the ground. While the change in virulence is believed to diminish upon return to Earth, this study was the first to show that some bacteria, like *Salmonella*, may change their ability to cause disease during flight.



Salmonella grown in flight showed the presence of a material resembling a biofilm not seen in ground control



Mathematical models of fluid shear (shown above) indicate that the effect of space flight on microorganisms may change depending on the fluid forces on the bacterial surface

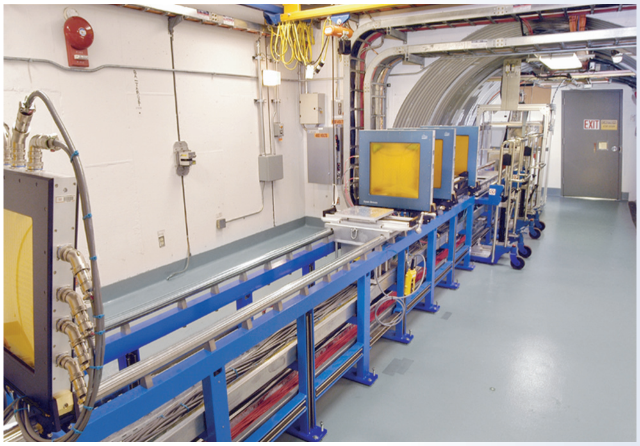
Based upon current knowledge, NASA's conservative monitoring and design requirements are effective in minimizing infectious disease risk of the crew. However, understanding the mechanism behind changes in virulence during space flight may lead to countermeasures to infectious disease if it occurs and help in the design of future bioregenerative and bioprocessing systems for the Moon and Mars.

Radiation Research

Space radiation poses acute and chronic risks to astronauts over their lifetimes such as cancer, central nervous system changes, chronic degenerative tissue changes, cataracts, and radiation sickness. Radiation both initiates and promotes cancer. For exploration missions, the exposure limits during a mission and on multiple missions have large impacts. Galactic cosmic rays present distinct challenges to exploration. An estimation of galactic cosmic ray risks has large biological uncertainties that currently preclude setting exposure limits. NASA needs to understand the effects of dose-rates of solar proton events for cancer. A lack of understanding could lead to over estimating shielding against these types of radiation, with a costly consequence. Today NASA space radiation permissible exposure limits set acceptable levels of risk to protect against the large uncertainties in risk assessment models.

The NASA Space Radiation Laboratory is a $34-million facility managed by NASA, located at the Department of Energy's Brookhaven National Laboratory on Long Island. It is one of the few places in the world that can simulate the harsh cosmic and solar radiation environment found in space. Researchers can use beams of heavy ions extracted from Brookhaven's Booster accelerator to study the effects of solar radiation. The laboratory has increased NASA's rate of space radiation research more than 5-fold from an average of 150 hours per year in 1995 through 2002 to more than 1000 hours per year in 2003 through 2007.

The Space Radiation Project utilizes a combination of individual researchers and five NASA Specialized Centers of Research (NSCORs) to understand the impact of space radiation on human systems. During 2007, the NSCOR located at Colorado State University studied the risk of leukemia for the first time with galactic cosmic ray nuclei. Leukemia has the shortest latency of all cancers and one of the highest mortality ratios. Findings from the Colorado State study show that iron nuclei produce leukemia through a mechanism (DNA instability) that is completely distinct from that produced by gamma-rays (classical gene deletion). Galactic iron nuclei are significant from a biological standpoint and represent a concern for long-term space missions.



NASA Space Radiation Laboratory

Other specialized centers of research at the University of Texas Southwestern, Tufts University, and Lawrence Berkeley National Laboratory are focusing on lung and breast cancer that encompass greater than 30% of cancers on Earth. Recent research made important progress using new technologies to understand telomere changes related to cancer. Telomeres cap the ends of human chromosomes, and modifications to telomere structure or regulation are important events in cancer and aging. Investigators at specialized centers of research at the University of Texas Southwest and Colorado State University in conjunction with scientists at the Johnson Space Center have made important progress. This is the first time that quantitative estimates of relative biological effectiveness factors of iron nuclei have been determined for telomere damage.

Lawrence Berkeley National Laboratory made another key breakthrough in understanding the relationship between the repair of radiation damage to DNA and aberrant tissue growth that occurs in cancer. Scientists understood the molecular events that control the responses of cells to DNA damage by radiation; however, understanding the process by which cells breakout from tissue regulation following genetic damage has remained obscure. For the first time the Berkeley researchers linked molecular controls responsible for DNA damage responses to controls on tissue regulation. Using a 3-dimensional human mammary cell culture model, they demonstrated that molecular controls on tissue regulation will eliminate key cellular responses to DNA damage. This breakthrough result published as the cover article on the leading journal "*Cancer Research*" will lead to the development of improved models of space radiation risks and for new strategies in cancer treatment on Earth.

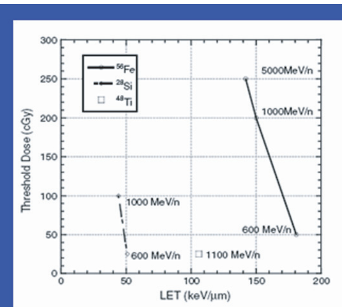


Figure: Threshold doses for Silicon, Titanium and Iron nuclei for disrupting performance in rats (Rabin, et al. 2007)

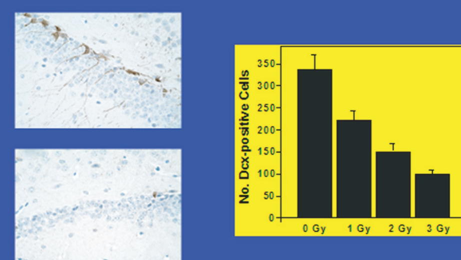
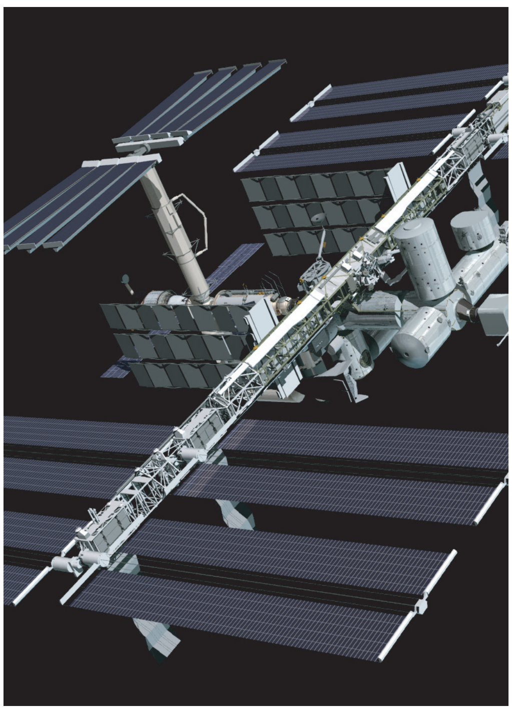


Figure: NSRL results for reduction in number of neurons (neurodegeneration) for increasing Iron doses in mouse hippocampus (P.I. J. Fike, USF)

NASA Space Radiation Laboratory results

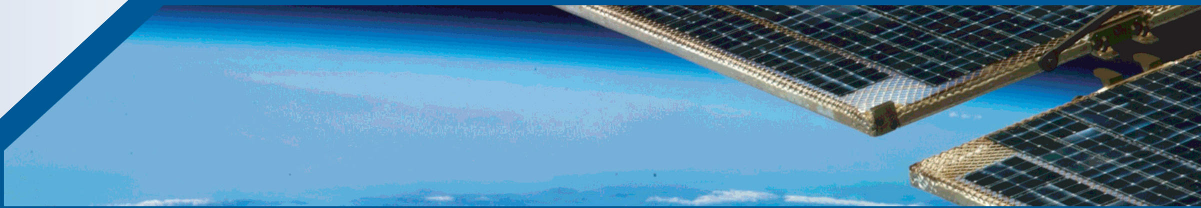
The Human Research Program Utilization Plan for the International Space Station

The International Space Station (ISS), as an orbiting, microgravity laboratory, provides an invaluable platform to acquire knowledge, test countermeasures, and evaluate technologies important for the development and validation of risk mitigation techniques for exploration missions. It is critical for NASA to use the facilities on the Station to the maximum extent possible while it is available. The activities on the Station are essential for either of two reasons. First, because there is no effective ground-based analog to conduct the work on Earth, or second, the research activity needs the complete operational environment of spaceflight to validate the countermeasure or technology.



Artist rendering of the completed International Space Station

With the Station planning to complete operations in 2016, it is imperitive that the HRP understand the impact of losing this resource. To meet the HRP goals, NASA analyzed the value and necessity of the International Space Station to quantify the human health and performance risks for crews during exploration missions. Based on a set of 32 exploration risks, the HRP defined a research and technology plan for use of the station to identify and quantify risks to human health and performance, to identify potential countermeasures, and to flight validate those countermeasures. Twenty-five of the 32 risks require the use of the Station beyond the planned 2016 completion. The research plan for various risks is laid out as a progression of activities that are designed to address critical questions that must be answered to quantify the risk or develop mitigation strategies for the risk. Publication of analysis results in the "Human Reseach Utilization Plan for the International Space Station" allows Agency management to make informed decisions on the future of this valuable resource beyond 2016.

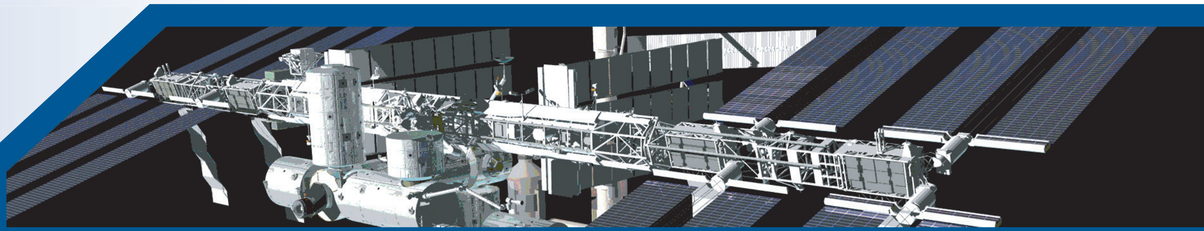


Research Elements Overview

The HRP utilizes the six elements to mitigate human health and performance risks and to establish the evidence base on which human spaceflight health standards are based. These standards include fitness for duty standards that define the physiological and behavioral parameters necessary to maintain performance; the permissible exposure limits during spaceflight conditions; and levels of care standards that define the medical capabilities needed to respond to a medical contingency. The descriptions and detailed accomplishments for each element are discussed in the following sections.

The elements include:

- International Space Station Medical Project
- Space Radiation Element
- Human Health Countermeasures Element
- Exploration Medical Capability Element
- Space Human Factors and Habitability Element
- Behavioral Health and Performance Element



International Space Station Medical Project

The International Space Station Medical Project (ISSMP) provides optimal utilization of NASA's precious flight resources, enabling research needed to close knowledge gaps and reduce the risks to the human system during exploration missions. The Project provides the bridge between flight research and medical operations by planning, integrating, and implementing human research requiring access to the Station, Shuttle, Soyuz, Progress, or other spaceflight vehicles. This support spans preflight and postflight ground activities and inflight science operations. It also includes access to on orbit assets including sustaining engineering of the Human Research Facility.

The Project works with the Space Medicine Division, other HRP elements, and international partners to return the data needed to address key risk areas. The ISSMP also flight-validates a suite of integrated physiological, pharmacologic, and nutritional countermeasures designed to mitigate the effects of the spaceflight environment that could affect mission success or crew health and safety on exploration missions.

The ISSMP coordinates with the Space Station Payloads Office to streamline the processes for station usage, to increase the research output, and to maximize the sets of data that can be returned to guide future research to meet the objectives of the risk reduction program. For additional information on the International Space Station Medical Project visit:
http://humanresearch.jsc.nasa.gov/elements/issmp.asp.

Major Accomplishments using the Station

The ISSMP maintains a continuous flow of research experiments in various stages of completion. For Shuttle (short-duration) and ISS (long-duration) missions in 2007, 5 experiments completed flight data collection, 5 new experiments were initiated and 8 continued on-going data collection. The data are returned to the Element requesting access to spaceflight resources for analyses.

Renal Stone Risk during Space Flight: Assessment and Countermeasure Validation

The Renal Stone experiment, which began inflight operations on Expedition 3, completed its 20th and final subject during Expedition 14. All remaining inflight samples were returned in June on STS-117. The renal stone experiment tested the effectiveness of potassium citrate in reducing the risk of renal stone formation during long-duration spaceflight. Bone loss, known to occur in space, significantly increases the amount of calcium in the urine. This increase coupled with decreased fluid consumption can lead to the formation of renal (kidney) stones.

Thomas Reiter on ISS processes samples for the Renal Stone investigation

The formation of a renal stone could have severe health consequences for crewmembers, and it cannot be treated during a mission as it can be on Earth. Minimizing the risk of stone-formation is vital to ensuring the health and safety of crewmembers. This study examines the potential for developing renal stones in space crews and the effectiveness of a pharmaceutical countermeasure, potassium citrate. Potassium citrate is a proven ground-based treatment for patients suffering from renal stones. This experiment required crewmembers to ingest potassium citrate daily inflight, perform 24-hour urine collections, and log diet early, mid and late in the increment. Ultimately, these data will not only help long-duration spaceflight crews but also will aid those on Earth in understanding how renal stones form in otherwise healthy persons.

Analyzing Interferometer for Ambient Air (ANITA)

The ANITA payload successfully launched in August on STS-118 and was subsequently installed in an Expedite the Processing of Experiments to the Space Station rack on the ISS. It has been in continuous operation since Expedition 15. The ANITA is a joint project between NASA and the European Space Agency (ESA). The ESA provided the ANITA instrument, while NASA provided accessory equipment and payload integration support. ANITA is a Fourier Transform Infrared technology-based, trace gas, monitoring system that is being tested for accuracy and reliability as a potential next-generation atmospheric trace gas monitoring system for the station. The instrument is calibrated to simultaneously monitor 32 gaseous contaminants at low concentrations in the cabin atmosphere without changing the physical or chemical properties of the gas sample. Its quasi on-line, fast time resolution analyzes air quality and in the future could be used for immediate initiation of countermeasure(s), if required. The ANITA is currently analyzing ambient air samples every 6 minutes on-board the ISS, with the data transmitted to the ground daily for analysis by the ESA science team.

Nutritional Status Assessment

The Nutrition investigation was initiated this year with the first data collection on Expedition 14. Frozen samples from the first subjects were returned in August on STS-118. This study is the most comprehensive inflight study to date of human physiologic changes during long-duration spaceflight. It includes measures of bone metabolism, oxidative damage, nutritional assessments, and hormonal changes. This study will impact both the definition of nutritional requirements and development of food systems for future space exploration missions to the Moon and Mars. This experiment will also help to understand the impact of countermeasures (exercise and pharmaceuticals) on nutritional status and nutrient requirements for astronauts. Inflight operations for this experiment required periodic blood draws and 24-hour urine collection sessions from the astronauts. This investigation is expected to run through Expedition 19 planned for 2009.

Sunita Williams inserting blood samples into the Minus Eighty Degree Laboratory Freezer

Cardiovascular and Cerebrovascular Control on Return from ISS (CCISS)

Data on the first subject for the CCISS experiment was collected during Expedition 15. The principal investigator for this experiment is sponsored by the Canadian Space Agency, with NASA sponsoring the flight opportunity. This investigation examines the effects of long-duration exposure to microgravity on crewmembers' cardiovascular (heart functions and blood pressure) and cerebrovascular (blood vessels that supply the brain) systems.

During the pre and postflight testing, crewmembers participate in the baroreflex study to collect data on the control of blood pressure. Testing includes use of ultrasound imaging as a non-invasive method to examine blood flow to the brain and the heart. Crewmembers also participate in the lower body negative pressure (LBNP) protocol. The Lower Body Negative Pressure device creates a partial vacuum on the crewmember that pulls blood and other fluids away from the heart to provide data on control of blood pressure. The data gathered during this investigation will lead to countermeasures to help crewmembers maintain sufficient blood pressure after long-duration missions, especially crewmembers who are susceptible to fainting after landing.

Clayton Anderson working with the Continuous Blood Pressure Device for the Cardiovascular and Cerebrovascular Control on return from ISS experiment

Test of Midodrine as a Countermeasure against Postflight Orthostatic Hypotension (Midodrine)

Researchers initiated the Midodrine study to evaluate the effectiveness of the medication, midodrine, in preventing the low blood pressure (hypotension) that some astronauts experience upon returning to Earth. When blood pressure drops, usually upon standing, the result is lightheadedness or even fainting because of the decreased blood flow to the brain. Approximately 20% to 30% of crews on short-duration (less than 20 days) missions and 83% of crews on long-duration missions experience some degree of hypotension after return to Earth.

During the preflight period, participating crewmembers perform a tilt test. This test is designed to evaluate the ability of the body to regulate blood pressure in response to stresses. Blood pressure is regulated by the way the heart beats and by the size of blood vessels. Prior to landing the crewmember ingests a dose of midodrine and immediately after exiting the vehicle participates in a tilt test. During the past year, Midodrine was successfully tested on the first two short-duration subjects during the STS-116 and 118 missions. In the next year, the first data collection on long-duration subjects will occur and requires additional inflight operations consisting of an electrocardiogram to record the electrical activity of the heart and measure the rate and regularity of heartbeats.

Midodrine has been used extensively on Earth to treat patients with low blood pressure. Current countermeasures for spaceflight induced hypotension have not been completely effective, thus midodrine may provide a relatively simple method for preventing a significant obstacle to long-duration spaceflight.

Astronaut John L. Phillips during a tilt table test, in Baikonur, Kazakhstan

Stability of Pharmacotherapeutic and Nutritional Compounds (Stability)

Scientists studying the stability of pharmaceutical and nutritional compounds are assessing the effects of the space environment on complex organic molecules, such as vitamins and other amino acids in food and medicine. Results will help researchers develop more stable and reliable pharmaceutical and nutritional countermeasures suitable for future long-duration missions to the Moon and Mars. Previous analyses of certain medications returned from the Shuttle and International Space Station indicated that some pharmaceuticals are significantly degraded by exposure to the space environment. This may compromise treatment and health of crews on future exploration missions. The project will identify those pharmaceuticals and nutrients that degrade in space and assess the magnitude and time course of degradation. This information can be used in mathematical models to predict the shelf life of products for long-duration exploration missions and guide future efforts to develop alternative formulations, packaging, and shielding materials for medicines and foods. For example, NASA may need these alternative methods of preparing, dispensing, and storing medication to improve stability and minimize loss of potency during missions to Mars.

Four identical sample kits (containing pharmaceuticals, food, a dosimeter, and a temperature sensor) were delivered to the ISS in July 2006 on STS-121 and will be stored for various time durations prior to return to Earth for analysis. The first kit was returned with the STS-121 mission. The second kit was returned in June 2007 on STS-117. Following return to Earth, the sample kits from space will be scientifically compared to identical sample kits that remained on Earth and were not exposed to the space environment.

Periodic Fitness Evaluation with Oxygen Uptake Measurement (PFE-OUM)

The PFE-OUM study is the first to directly measure the changes in cardiovascular fitness during the course of a long-duration stay in space. While on the Station, the crewmembers perform a monthly fitness evaluation. During the fitness evaluation, heart rate and blood pressure are recorded while exercising. This allows ground-based exercise physiologists and flight physicians to estimate crew health and fitness and accurately prescribe exercise countermeasures. With this new equipment that measures oxygen uptake, a wide range of respiratory and cardiovascular measurements can be made that more accurately reflect the physical fitness of the crew. The PFE-OUM experiment is a collaborative effort between the European Space Agency and NASA. Phase II of the study began on Expedition 15, with the capability for direct communication of data from the cycle ergometer and the Pulmonary Function System.

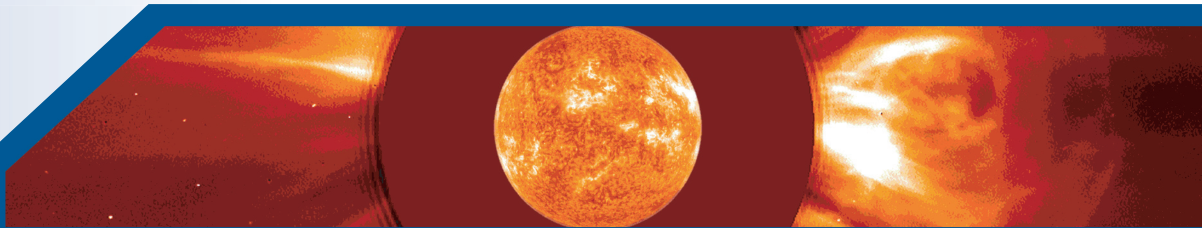
Sunita Williams exercises on the cycle ergometer during the Periodic Fitness Evaluation with Oxygen Uptake Measurement (PFE-OUM) experiment

Validation of Procedures for Monitoring Crewmember Immune Function (Integrated Immune)

Previous observations suggest that space flight may have a negative impact on different elements of the immune system. The objective of this investigation is to develop and validate an immune monitoring strategy. This study collects data on both short and long-duration crewmembers. Inflight data collection on long duration crews started operations in October on STS-120 and Expedition 16. Participating crewmembers in this experiment collect saliva and blood samples periodically during the flight. The blood samples are collected late in the flight and the samples stored at ambient temperature and returned are retrieved from the Shuttle as soon as possible for analysis of the live cells.

The Integrated Immune study assesses the clinical risks resulting from the adverse effects of spaceflight on the human immune system. Changes in the immune system may be a result of microgravity, confinement, physiological stress, radiation, and environmental or other mission-associated factors. The clinical risk from prolonged immune dysfunction could be significant and may include increased incidence of infection, allergic reactions, hypersensitivity, hematological malignancy, or altered wound healing. The clinical risk associated with prolonged exploration-class space flight is significantly higher than for Earth-orbital flight. Each of the clinical events resulting from immune dysfunction has the potential to impact critical mission objectives during long-duration spaceflight. Characterization of the clinical risk and the development of a monitoring strategy are necessary prerequisite activities for validating countermeasures. In addition, the strategy validated during this investigation will have significant benefit for the routine monitoring of crewmember's immune system status with regard to diagnosis and prognosis of immune-related disease states.

Integrated Immune Blood Collection Kit



Space Radiation Element

The goal of the Space Radiation Element is to ensure that crews can safely live and work in the space radiation environment without exceeding the acceptable radiation risks. Space radiation differs from radiation encountered on Earth[1] and the health risks from space radiation may include an increased incidence of cancer, acute radiation sickness, and degenerative tissue damage, including damage to the central nervous system (CNS), heart disease, and cataracts. Space radiation risks have clinically relevant implications for the lifetime of the crew. For this reason, space radiation studies rely on biomedical and radiation physics expertise to provide:

- Recommendations to space radiation permissible exposure limits for exploration missions
- Radiobiological data, projection models, and computational tools to assess and project crew risk of cancer, CNS and degenerative tissue risks, and acute radiation syndrome from space radiation
- Computational tools and models to assess vehicle design for radiation protection
- Assessment of updated technologies if needed, for monitoring radiation exposure, and recommendations on technologies to be used operationally
- Uncertainty reductions to enable radiation protection design and crew constraints for lunar and Mars missions
- Assessments of the effectiveness and development of physical or biological countermeasures

The results of space radiation studies contribute to the exploration initiative by assessing the risks to crew while reducing uncertainties that cannot be derived from terrestrial radiation studies. The results will also provide tools for evaluating shielding recommendations for habitats and vehicles and requirements for storm shelter and early warning systems for solar particle events. To read more about the Space Radiation Element, please visit: **http://humanresearch.jsc.nasa.gov/elements/radiation.asp**.

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[1]The primary sources of radiation in space are galactic cosmic rays (GCR), which consist of protons and electrons trapped in Earth's magnetic field, and solar particle events (SPE). GCR permeates interplanetary space and includes high ionizing energy (HZE) particles. They cause damage at the cellular and tissue levels unlike the damage caused by the terrestrial radiation such as x-rays or gamma rays because of the significantly higher ionizing power, greater potential for radiation-induced damage, and greater penetration power of HZE particles.

Major Accomplishments

The NASA Specialized Centers of Research (NSCORs) major accomplishments in 2007, previously discussed, will focus ground-based radiation studies and future research solicitations for the next few years. Early this year, NASA and the NSBRI released a joint research announcement, Ground-Based Studies in Space Radiation, with the major focus on radiobiology research. The experiments will use beams of high energy heavy ions simulating space radiation at the NASA Space Radiation Laboratory. Of the 98 proposals received, 72 were invited to submit step-2 proposals in the areas of radiation biology for the Space Radiation Element and dosimetry for the NSBRI. Peer review of the 64 step-2 proposals occurred in early summer with 17 selected from universities, research institutions, and private companies in 8 states.

Fifteen competitively selected students attended the 2007 NASA Space Radiation Summer School held at Brookhaven National Laboratory in late June. The students and 4 auditors included graduate students and faculty in biology and physics, foreign and domestic students, and lecturers working with course director, Dr. Eleanor Blakely from the Lawrence Berkeley National Laboratory.

NASA researchers held a number of workshops to focus the radiation research community on the needs anticipated to design future exploration missions. The Space Radiation Measurements and Transport Physics Workshop focused on reducing uncertainties by increasing knowledge of light ion physics and exploring advanced methods to transport ion beams.

During the second meeting of the National Academy of Science Committee on Radiation Shielding for Lunar Exploration, the committee was briefed about the Constellation Program challenges regarding radiation shielding. Topics included the crew exploration vehicle, the lunar lander, lunar habitats, and lunar extravehicular activities. NASA researchers described radiation shielding design, solar forecasting, and solar weather. In addition, NASA co-sponsored the 4th Annual International Workshop on Space Radiation Research held in Sonoma, California. Every 3 years the Space Radiation Element combines its annual investigators' meeting with International Partners and publishes the proceedings in prestigious journal supplements.

Since 2003, NASA has funded peer-reviewed research on the radiobiological effects using beams that simulate the cosmic rays found in space at the NASA Space Radiation Laboratory. To develop accurate estimates of radiation-associated risks to human beings in space and identify countermeasures for reducing those risks, NASA researchers participated in three sessions at Brookhaven during 2007. During these sessions, scientists irradiated a variety of biological specimens, tissues, and cells during a total of 1100 hours of beam time. To read more about this facility visit:
http://spaceflight.nasa.gov/shuttle/support/researching/radiation/.

Human Health Countermeasures Element

NASA uses the term countermeasures to describe the procedures, medications, exercise, and other strategies that help to keep astronauts healthy and productive while they are traveling in space and after they return to Earth. The Human Health Countermeasures Element is responsible for understanding the physiological effects of spaceflight and developing countermeasure strategies and procedures. They use a number of settings to research and test potential countermeasures. Optimally, all countermeasures will eventually be validated in flight or on the lunar surface during operations. However, prior to flight-testing, many candidate countermeasures and technologies are assessed using flight analog environments. Example analog settings include: bed rest, undersea habitats, Antarctica outposts, and other environments that simulate some aspect of space flight.

The goal is to develop and validate an integrated suite of countermeasures for exploration missions. These countermeasures will maintain human physiological and performance capabilities so that crews can perform all required duties during the many phases of an exploration mission. These phases include time in microgravity, transitions from Earth's 1-G environment to low-Earth orbit, to the 1/6 gravity of the Moon, back into space, and return to Earth. They encompass preflight, postflight, and inflight activities. Preflight countermeasures involve limiting exposure to contagious diseases, physical conditioning, and physiologic adaptation training. Inflight countermeasures include exercise, nutritional, pharmacological, and physical (G-suits, suit design, prebreathe) activities. Postflight treatments target rehabilitation strategies.

Major Accomplishments

The diverse Human Health Countermeasures Element comprises five projects that address exercise, non-exercise, and extravehicular activity (EVA) countermeasures as well as flight analog facilities and computational modeling to help test and integrate potential countermeasures before their actual flight verification.

Major accomplishments are described by each project:

- Exercise Countermeasures Project
- EVA Physiology, Systems and Performance Project
- Flight Analogs Project
- Non-Exercise Physiological Countermeasures Project
- Digital Astronaut Project

For more information, please visit the Human Health Countermeasures Element website at **http://hacd.jsc.nasa.gov/projects/hhc.cfm**.

Exercise Countermeasures Project

The Exercise Countermeasures Project (ECP) provides exercise hardware and monitoring equipment in addition to the exercise prescriptions to optimize the health and performance of flight crews for exploration missions.

Sunita Williams calibrates the oxygen uptake hardware for her Periodic Fitness Evaluation

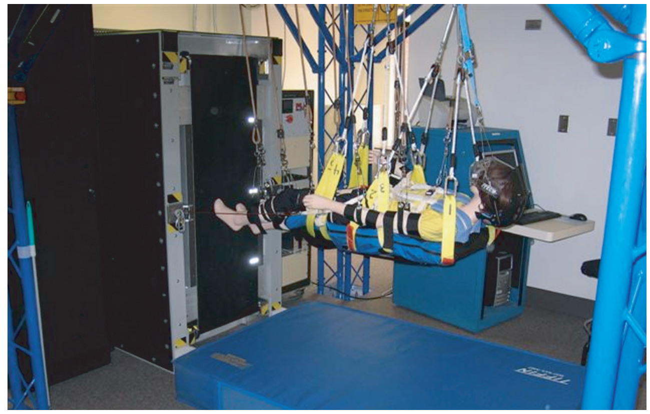
The project uses studies performed on the Shuttle and International Space Station to quantify program risks and identify improved exercise countermeasures for exploration missions. To track changes in on-orbit aerobic capacity, an indicator of cardiac health, the project initiated a flight investigation during 2007 to measure maximal oxygen uptake during ISS missions using the European Space Agency's Portable Pulmonary Function System. Preliminary testing of the maximal exercise protocol was completed this past year, to ensure the accuracy of planned on-orbit measurements of oxygen consumption. The investigation is expected to begin inflight data collection during Expedition 19, currently scheduled for 2009.

The ECP completed testing of 20 subjects who participated in an exercise training study with the Advanced Resistive Exercise Device (ARED), planned for deployment to the space station in 2009. The device will allow a greater number and variety of exercises and substantially higher resistive exercise loads compared to the current resistive exercise device. Subjects in this study completed 16 weeks of training to compare muscle, bone, and functional performance gains using the ARED versus free weights. Preliminary results indicate the ARED is as effective as a similar training regime using free weights.

The Project initiated the development of a treadmill harness that will provide greater comfort and allow more loading during on orbit exercise sessions. In order to mimic exercise on Earth, astronauts use a harness to hold them on the treadmill while adding a downward force similar to the effects of gravity on Earth. The previous version of the harness causes friction at the waist and shoulders resulting in tenderness and broken skin. Researchers working with the Cleveland Clinic Center for Space Medicine designed a new harness that fits more comfortably and allows astronauts to exercise at higher loads. The inflight testing of this harness is expected to begin with Expedition 19, scheduled in May 2009.

Astronaut Sunita Williams, equipped with a bungee harness, exercises on the Treadmill Vibration Isolation System (TVIS)

The ECP completed construction and installation of a vertical treadmill system, the Standalone Zero Gravity Locomotion Simulator, at the University of Texas Medical Branch in Galveston. The simulator is used during bed rest studies to develop exercise devices and procedures that simulate the effect of extravehicular activity on physiologic systems.



Standalone Zero Gravity Locomotion Simulator (sZLS) set up with manikin at the University of Texas Medical Branch (UTMB)

EVA Physiology, Systems and Performance Project

Extravehicular Activity (EVA) will be an integral component of the success of future exploration missions to the moon and Mars with unprecedented duration and new challenges with regard to crew health, safety, and performance. As part of the Human Research Program, the EVA Physiology, Systems and Performance Project works with the Constellation Program EVA Systems Project to develop and execute an integrated human testing program across multiple analog environments. Studies are performed to collect the objective data needed to develop evidence-based requirements and to make informed decisions for the design of an advanced EVA suit. These data will also guide operational decisions for EVA timelines that optimize human health, safety, and performance in reduced gravity environments.

During 2007, tests were conducted using a number of reduced gravity analog environments that simulate lunar EVA conditions: the Neutral Buoyancy Laboratory, the Partial Gravity Simulator in the Johnson Space Center Space Vehicle Mock-Up Facility, and during NASA Extreme Environment Mission Operations (NEEMO). These tests were aimed at understanding the factors that may affect human performance while working in an EVA suit. Factors studied include suit weight, mass, center of gravity, pressure, and kinematic constraints. Subjects performed exploration EVA-type activities, such as ambulation on level and inclined surfaces, ambulation while carrying a load, rock collecting, shoveling, kneeling, recovering from a fall, and simple exploration and construction tasks using hand tools and power tools. Researchers collected data on metabolic rates, subject anthropometrics, time series motion captures, ground reaction forces, subjective ratings of perceived exertion, and operator compensation using the modified Cooper-Harper rating scale.

A new EVA suit, the MKIII demonstrator suit, was tested in the Partial Gravity Simulator and compared to matched controls working in a shirt-sleeve environment. This comparison allowed for a better understanding of the specific metabolic costs and biomechanics of the MKIII suit. The results of this test will allow investigators to develop a quantitative understanding of the interrelationships between the suit (weight, mass, pressure, center of gravity) and crew anthropometrics and performance. These data will guide future EVA suit development for optimized use in the targeted operational environment and will improve the ability to effectively plan EVA timelines and consumable usage.

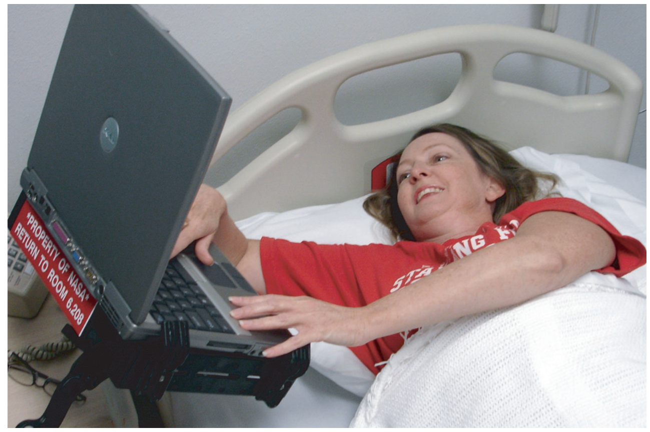
A test was also conducted at the 2007 Haughton Mars Project, briefly described earlier. The test took advantage of the landscape at the Haughton impact crater on Canada's Devon Island to investigate how the terrain, regolith, and navigation through the lunar landscape will affect a crewmember's ability to translate 10 km. This test was a follow-up to the EVA Walkback Test conducted in 2006, which established that it is possible for a crewmember to complete a 10 km walk-back from the exploration field back to the habitat in the event of a rover failure. Each subject performed three different walkbacks starting from different points in the field, but with each point set at 10 km of radial distance from the habitat. Metabolic rate, total horizontal and vertical distance traveled, and time to completion were measured. In addition, a treadmill control trial was completed, which matched the subject's speed, distance and grade to one of the field walkbacks. Comparison of the field and matched control data will be used to derive an EVA environment correction factor for metabolic rate studies conducted on a treadmill.

The EVA Physiology, Systems and Performance Project also performed operationally relevant physiological research to develop EVA prebreathe protocols. Astronauts preparing to perform EVA breathe 100% oxygen to reduce the risk of decompression sickness (DCS). Scientists worked to define acceptable decompression sickness risks for exploration missions. Physiologists continued studies to validate EVA prebreathe protocols for lunar surface operations that will meet medical, vehicle, and habitat constraints while minimizing crew time spent in prebreathe activities.

Developing the new EVA suit, planning EVA timelines, evaluating consumable use, and preventing DCS are all key areas that require attention as NASA returns to the moon and prepares to explore Mars. Results of these EVA Physiology, Systems and Performance Project studies will improve performance and maximize crewmember safety.

Flight Analogs Project

The Flight Analogs Project maintains a continuous flow of investigations in various stages of completion. Bed rest is a well established spaceflight analog to study changes in physiologic function associated with spaceflight. The model uses 90-days of 6-degrees head-down tilt bed rest as an analog for microgravity experienced during long-duration spaceflight. A battery of biomedical tests, called standard measures, are conducted on each subject to assess immune function, nutritional status, cognitive function, cardiovascular responses, exercise responses, neurological function, and bone physiology before, during, and after bed rest. A manuscript containing the results of these measures was completed in 2007 and is in review for publication in a 2008 special supplement of Aviation Space and Environmental Medicine. In addition to standard measures, investigator-initiated studies are also conducted in the bed rest facility. Results of the completed Artificial Gravity Pilot Study were submitted to the Journal of Gravitational Physiology for publication. The Flight Analogs Project continued 2 long-duration 6-degree head-down tilt studies continued over this past year. Data from these studies are given to the principal investigator or Element for analysis.



Bed Rest Campaign

- The first campaign uses bed rest to evaluate causal mechanisms for gender differences observed during postflight orthostatic hypotension tests. Scientists evaluated gender differences in arterial pressure control in conjunction with the vascular responsiveness of upper and lower extremities before and after 90 days of bed rest. Five subjects (4 males, 1 female) successfully completed this study in 2007.

- The second campaign uses bed rest to assess the efficacy of low-level mechanical stimulation as a countermeasure to inhibit bone loss associated with long duration space flight. Subjects received extremely low-levels of whole-body vibration for 10 minutes each day during 90 days of head-down tilt bed rest. In 2007, 10 subjects (7 males, 3 females) successfully completed this protocol.

Researchers understand that a 6-degree head-down tilt is analogous to the microgravity of spaceflight. To understand the bed rest profile that simulates lunar gravity, the Flight Analogs Project initiated the development of a lunar bed rest model. These studies will test a 9.5-degree head-up tilt device to simulate the effects of lunar gravity on bone, muscle, and cardiovascular systems. In collaboration with the Cleveland Clinic Foundation, studies are underway to assess the feasibility of this model for simulating whole body physiological effects of a lunar mission.

Non-Exercise Physiological Countermeasures Project

The Non-Exercise Physiological Countermeasures Project addresses cardiovascular, immunological, skeletal (bone), muscle, nutritional, pharmacological, and neurovestibular (sensorimotor) physiology. It is an operationally-driven research program seeking to understand and possibly mitigate spaceflight human health and performance issues. The project research portfolio contains 34 ongoing space and ground-based research studies performed by intramural and extramural investigators across the 7 physiologic disciplines.

Highlights for 2007 include initiation of the Integrated Cardiovascular flight study. This complex study combines intramural and extramural expertise in an effort to characterize the degree and causes of cardiac atrophy and diastolic dysfunction due to long-duration space flight. In addition, the study will determine operational consequences of any resultant orthostatic intolerance or arrhythmias. The study successfully completed preliminary design review and approval by the JSC Committee for the Protection of Human Subjects so that the study can commence on the Station for Increment 19. Cardiovascular investigators on this integrated study participated in an International Cardiovascular Technical Interchange Meeting to discuss sharing of flight resources and data among the several international partners who are sponsoring these cardiovascular flight experiments.

ESA's Thomas Reiter wearing a finger cuff (vest is visible on his knee) used to measure blood pressure and heart rate

Another project highlight was the Nutritional Biochemistry Laboratory study, "Efficacy of Vitamin D Supplementation in an Antarctic Ground Analog of Space Flight." Vitamin D is critical for space travelers because they lack ultraviolet light exposure (a source of vitamin D) and have an insufficient dietary supply of vitamin D. Despite the provision of vitamin D supplements to ISS crew members, vitamin D status is consistently lower after flight than before flight. Individuals wintering at

McMurdo Station, Antarctica participated in the study, a great analog for spaceflight and vitamin D because of lack of ultraviolet (UV-B) light exposure in winter months. A blinded supplementation study was conducted to evaluate three doses of vitamin D: 400 IU, 1000 IU, and 2000 IU. Blood samples and dietary intake data were collected from 57 subjects, with collections completed in September 2007. Samples and data products were delivered to JSC in October for analysis.

Also in 2007, nutrition and immunology investigators performed studies using another analog environment – NASA Extreme Environment Mission Operations (NEEMO), an undersea habitat located near Key Largo, Florida that mimics many aspects of short-term spaceflight. Both teams collected biological samples and performed analyses similar to current spaceflight studies to determine the validity of NEEMO as an analog with respect to spaceflight crew nutritional and immunological status. If results support the validity of this analog, NEEMO may provide an alternate platform for future evaluation and validation of proposed countermeasures in these disciplines.

Digital Astronaut Project

Predicting the effects of spaceflight on the human body can be very challenging. Longer, more physically demanding missions necessitate a better understanding of human physiology during spaceflight to establish health and safety requirements for these new missions. As part of the Human Research Program, the Digital Astronaut Project will develop a detailed computer model of the entire human body. This model can be used to predict the effects of spaceflight on each body system. Researchers have started developing detailed models of bone loss, kidney stone formation, and the heart. The computer model of the human body will be useful to the medical community to aid in understanding disease and lead to improvements in pharmaceuticals, surgical procedures, and treatments.

Accomplishments in 2007 included using computer simulation to predict the best configuration for a lunar bed rest analog. These studies are important to understand the effect of lunar gravity on muscle deconditioning and bone loss. A force calculation using basic physics would suggest that ten degrees of head up tilt is the bed rest angle that would simulate the foot force on bone of lunar gravity. Digital Astronaut, however, noted that lower limb dehydration associated with lunar gravity was not correctly modeled using that angle. To simulate both the appropriate foot force and dehydration, Digital Astronaut recommended a 10-degree head up tilt combined with compression stockings on the legs. The compression stockings forced the tissue to dehydrate appropriately. That is important because muscle changes in the legs affect the cardiovascular system and the ability of astronauts to return to normal gravity without fainting.

The Digital Astronaut is also attempting to understand changes in muscle metabolism due to reduced gravity. Quantifying these changes is important because reduced muscle strength may imply a reduced ability to conduct mission tasks. During the last year, personnel quantified cellular metabolic performance in laboratory animals following 2 weeks of exercise training. They then incorporated those data into a model of whole body adaptations to energy expenditure. The project also quantified changes in biochemical markers due to unloading of the muscles.

The Digital Astronaut Project will continue work in 2008 on detailed models of important physiological systems that are known to be negatively affected by spaceflight. These more detailed models will be tied to the integrated system simulation to quantify a more complete physiological response. For example, astronauts are at an increased risk to develop kidney stones. Using formalisms adopted from the crystal growth literature, a model of kidney stone formation was developed. Data from archival medical journals is being used to ensure that the model correctly represents the pathophysiology of kidney stone formation. Once this process, known as validation, is complete, the model will be integrated with the whole body level simulation to understand why astronauts have a greater risk for kidney stones. That knowledge, in turn, may eventually be used to develop protocols to limit kidney stone formation during long-duration exploration missions.

Exploration Medical Capability Element

During missions to the Moon or to Mars, the crew will need medical capabilities to diagnose and treat injury or disease as well as maintain their health. The Exploration Medical Capability Element develops medical technologies, data handling capabilities, and clinical procedures for different levels of care during space missions. The work done by team members in this Element is leading-edge technology, procedure, and pharmacologic development. The Element develops data systems that protect patient private data, aid in the diagnosis of medical conditions, and act as a repository of relevant NASA life sciences experimental studies. To minimize the medical risks to crew health the physicians and scientists in this Element develop models to quantify the probability of medical events occurring during a mission. They define procedures to treat an ill or injured crewmember who does not have access to an emergency room and who must be cared for in a microgravity environment where both liquids and solids behave differently than on Earth.

Human exploration of the Moon and Mars presents significant, new challenges to crew health:

- Hazards created by traversing lunar or planetary surfaces
- Effects of exposure to a number of different gravity environments
- Limitations on communications with ground-based personnel for consultation and diagnostic assistance for medical events

Providing health care capabilities that overcome these challenges requires new health care systems, procedures, and technologies to ensure the safety and success of exploration missions. In addition, exploration levies new requirements on data management. The Exploration Medical Capability Element is developing new approaches to catalog information so that it can be queried and analyzed. New methods are needed to train medical personnel who may not have access to experts for consultations. Developing these capabilities are the goals of the Exploration Medical Capability Element.

Major Accomplishments

The Exploration Medical Capability Element made strategic progress toward expanding NASA's ability to monitor, diagnose, and treat crews on exploration missions. One innovative research project developed a lightweight, wearable sensor that is incorporated into a sheet of metal rubber and worn in the garment. The sensor includes flexible electrodes and can be used for autonomous health monitoring while an astronaut is on the surface of the Moon. The garments with the wearable metal rubber textile sensors were lightweight, stretchy, and comfortable compared to conventional metal wiring. The company that produces this technology, NanoSonic Inc., was presented with a 2007 Research and Development (R&D) 100 award for this ground-breaking technology.

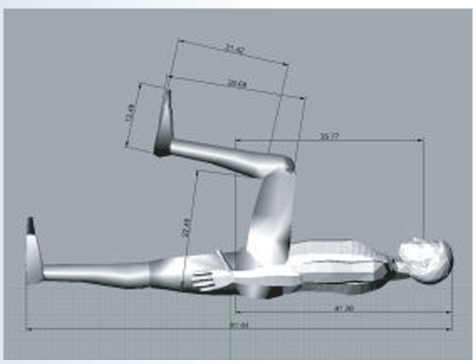
The ability to generate medical-grade water during flight greatly enhances NASA's ability for medical treatment. In addition, there are significant savings of resources if water does not need to be launched and stored for a lengthy exploration mission. The ability takes on additional importance because medical-grade water has a limited shelf life. The technology challenges however are significant. During 2007, the Exploration Medical Capability Element initiated a project to develop an inflight intravenous generation capability. The prototype device is expected to undergo inflight testing in 2009.

Another significant accomplishment was the completion of the risk module for bone fracture and other work on an integrated medical model. The team compiled a list of medical conditions that have occurred, or have a likelihood of occurring during space flight. For each of these conditions, the integrated medical model statistically combines data on the number of incidents from various programs such as Apollo, Mir, Skylab, Shuttle, and the International Space Station; with real data on crew age and gender, with data from analogs such as bedrest and Antarctica. Examples of the conditions seen in these programs include broken bones, myocardial infarction, and renal stones. The integrated model can be used to forecast the probability of a variety of medical conditions occurring during an exploration mission and identifying the capabilities and supplies that will be needed to treat a given condition.

Medical-grade water testing during parobolic flight

Space Human Factors and Habitability Element

Engineers and scientists in the Space Human Factors and Habitability Element develop standards and models that aid in the design of spacecraft, habitat systems, and hardware that are compatible with the physical and cognitive capabilities of crewmembers during space flight. This is the emphasis of the Space Human Factors Engineering Project. For example, experts are in the process of updating NASA's Human-Systems Integration Standard, NASA STD-3000. The revised standard will be comprised of two volumes: Volume 1 – Crew Health; Volume 2 – Habitability and Environmental Health. These two volumes contain general standards that are applicable to all human spaceflight programs, and will be accompanied by the Human Integration Design Handbook. This handbook will provide the data, information, guidance, and lessons learned needed to derive future program-specific requirements and vehicle and hardware designs.



Critical dimensions from a human model

Thomas Reiter collects a surface sample to characterize the microorganisms and allergens on the ISS

Another aspect of this Element studies the habitable environment of exploration spacecraft and develops astronaut exposure limits for potential contaminants of that environment. The Advanced Environmental Health Project addresses aspects of environmental exposure limits and monitoring, with the exception of radiation. Of major concern to NASA, are the potential health effects of crew exposures to lunar dust during lunar sortie and lunar outpost missions. Apollo experience indicates that the lunar dust, in the absence of stringent controls, will be ubiquitous in lunar landers and habitats. Studies have shown that lunar dust is highly unique in many important respects and warrants further study before safe exposure limits can be set. In addition, experts are characterizing microbial contaminants onboard the station and developing models to help evaluate risks to crewmember health resulting from exposure to these microbial contaminants. These models will be used to help ensure that microbial risks to current and future crewmember health are managed and well-controlled.

A third part of this Element, the Advanced Food Technology Project, provides crews with nutritious and palatable foods and the systems to safely store, preserve, and serve food. Food scientists are also designing equipment that minimizes the use of precious space resources such as weight, volume, waste, power, and trace gas emissions. A particular challenge is to improve food packaging, a major source of weight and waste. Keeping foods safe for long-duration missions, while maintaining the nutrition content and providing the variety that will meet the tastes of an international crew, is another challenge.

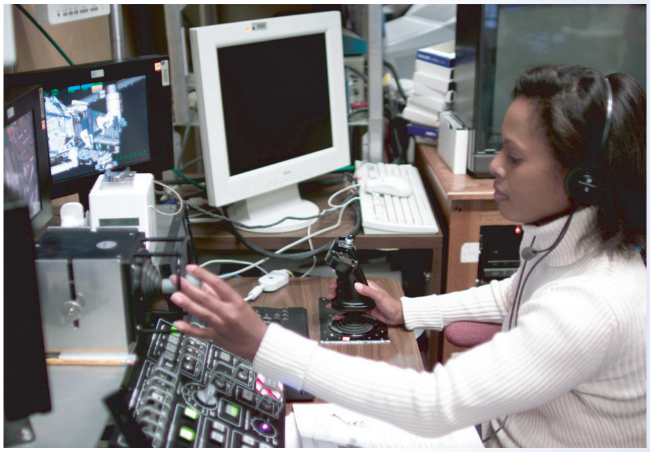
Major Accomplishments

The major accomplishments of this diverse Element are included below by project: Space Human Factors Engineering Project, Advanced Environmental Health Project, and Advanced Food Technology Project.

Space Human Factors Engineering Project

The review and update of NASA STD-3000 made significant progress. Volume 1 of the new standard was baselined and Volume 2 is in the final stages of review. The content of the new Human Integration Design Handbook will be a significant update to the content of NASA STD-3000 and will incorporate the recommendations resulting from studies and evaluations of the Rhode Island School of Design.

Manipulating remote devices, such as the robotic arm, is challenging, particularly in bright sunlight and deep darkness. These lighting conditions are particularly difficult in the vacuum of space because light does not scatter and shadows are intense. In addition, astronauts are moving large objects into precise positions, operations that can take hours. During one operation, the space station travels through bright sunlight and deep darkness every ninety minutes. Researchers successfully developed and tested overlay software for a robotic extension device. Use of the overlay dramatically improved an astronaut's ability to perform tasks outside of the space station without leaving the vehicle. Results of the research were presented at the Human Factors and Ergonomics Society 51st Annual Meeting on October 3 in Baltimore, Maryland.



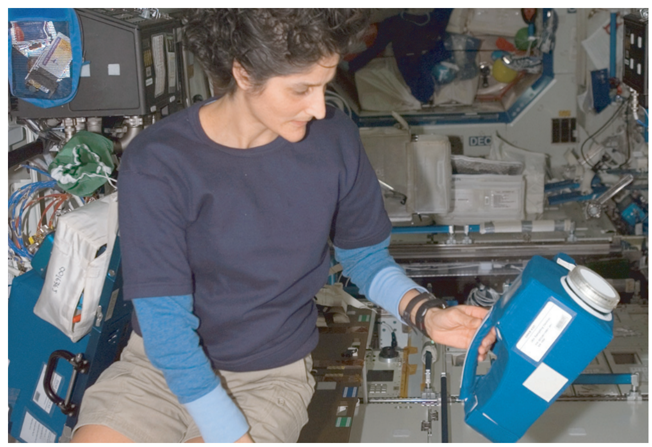
Mission Specialist, Joan Higginbotham, practicing at the controls of the Remote Manipulator System

The project completed a study looking at the characteristics needed by astronauts wearing space suit gloves to efficiently use electronic cursor control devices. Gloves reduce tactile feedback and resulted in study participants frequently visually checking where their fingers were on the devices. Researchers examined 8 cursor control devices using a a test battery of seven tasks that need cursor control such as pointing, dragging, and text selection. The tests looked at accuracy, speed, and fatigue. Results showed that each device had some characteristics that worked well with gloves either because of their larger size or because they did not allow for accidental movements which can cause errors. Lateral movements using the whole hand were easier than movements of the individual fingers. In addition, bending the fingers was very fatiguing for all participants and made the drag and drop tasks the most difficult.

Advanced Environmental Health Project

The surface, water, and air biocharacterization experiment is a comprehensive characterization of microorganisms and allergens on the Station. This experiment began inflight operations on Expedition 13 and completed the final inflight data collection session for surface samples during Expedition 15. The procedure involved obtaining samples from various surfaces throughout the Station and air samples. These were collected prior to the eight vehicle dockings with the station using unique hardware flown specifically for this investigation. Previously, culturable bacteria and fungi have been the only allergens studied. As a result, using this culture-based methodology, greater than 90% of all microorganisms including pathogens such as *Legionella* and *Cryptosporidium* were omitted. Microbial toxins and the more potent allergens, such as dust mites, have not previously been analyzed in spacecraft environments.

This study tested non-culture-based technologies such as molecular biology, advanced microscopy and immunochemical techniques, to look for microorganisms not previously reported in spacecraft. Samples were analyzed for bacteria and fungi (total composition and specific pathogens), pathogenic protozoa, specific allergens, and microbial toxins. The results showed a three-fold improved identification capability by converting to a molecular identification technique for bacteria. However, there was no indication that culture-based methodology is missing medically significant organisms. This experiment greatly advanced NASA's capability to select usable hardware for a lunar habitat.



Sunita Williams conducts air sampling in the Destiny laboratory of the International Space Station

Advanced Food Technology Project

New ways to package foods for long duration space flight are important for successful exploration missions. NASA held an advanced food packaging workshop with participants from academia, government, and industry. Those attending exchanged information on currently available and emerging packaging materials and technologies.

A 3-year accelerated shelf life test of thermostabilized food items was completed in 2007. Food items require a 5-year shelf life for a Mars mission. Four vegetable items, stored for 20 months, were tested and the results indicated that the shelf life for two vegetables was about 18 months, while the other two vegetables have at least a 2-year shelf life. Representative fruit and light colored carbohydrate thermostabilized food items were tested after 24 months. The testing suggests that these types of foods have at least a 2-year shelf life. In addition to the thermostabilized shelf life test, three bulk ingredients also requiring a 5-year shelf life completed a 3-year accelerated shelf life test. The final report was completed for cocoa powder, cornstarch, and dried egg whites showing that these ingredients did not lose their functionality for at least 3 years.

Behavioral Health and Performance Element

The Behavioral Health and Performance Element develops methods and technologies to aid crew performance in an isolated environment that can be stressful, where day and night cycles differ from the standard 24-hour Earth time and workloads can be heavy. This Element conducts research in various analog and flight environments to develop tools and technologies for monitoring and treating symptoms related to stress, lack of sleep, inadequate team cohesion, and crew performance. The end result is to optimize the adaptation of the individual and crew to the space environment and maintain motivation, morale, productivity, cohesion, and communication.

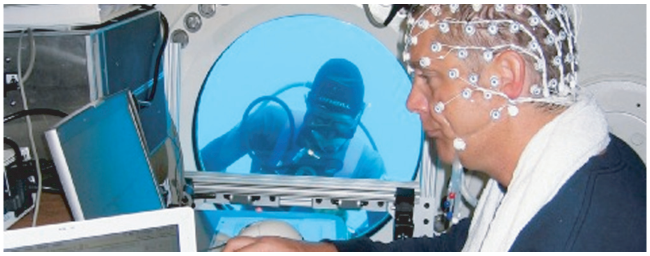
Cosmonauts and astronaut in the Zvezda Service Module of the International Space Station

Daniel Tani, Expedition 16 flight engineer, in a sleeping bag near two extravehicular mobility units

There are three primary areas of focus within the Element. The first area focuses on the risk of performance errors due to sleep loss, day-night issues, fatigue, and work overload. The second focus looks at performance issues related to poor team cohesion and performance, team composition, training, and psychosocial adaptation. The final area of research looks at the risk of behavioral and psychiatric conditions, and strongly focuses on early detection and treatment using unobtrusive, objective measures of cognitive and emotional states and stress reactions.

Major Accomplishments

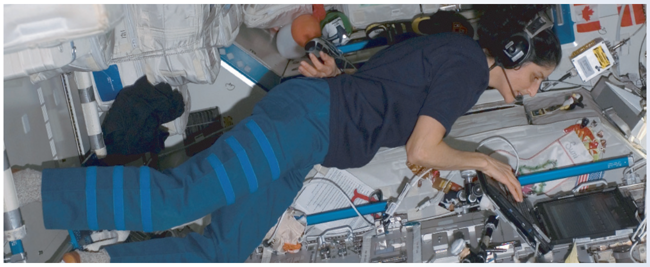
Extensive research was accomplished using the analog environment of the underwater facility, the NASA Extreme Environment Mission Operations (NEEMO) project. The facility operates 3.5 miles off Key Largo in the Florida Keys National Marine Sanctuary 62 feet below the surface. During operations, aquanauts are working at boundaries of physiological capability making this an ideal analog for spaceflight. Researchers completed studies on both aquanauts and support personnel working top side. These studies, done in partnership with NSBRI's Neurobehavioral and Psychosocial Factors Team, included measuring performance with the three-minute Psychomotor Vigilance Test, which evaluates vigilance, attention and psychomotor speed relative to fatigue. Other objectives included gathering performance data under 'high autonomy' conditions, when, similar to future exploration missions, crews manage their own timelines.



NEEMO 9 - aquanaut wearing a net with electrodes for an electroencephalogram (EEG) study

The NSBRI completed an Everest analog study where scientists tested a speech monitoring tool to detect increases in stress and potential hypoxia and radiation effects. This study was also used as the basis for development and testing of a computer algorithm to obtain acoustic voice measures that could be useful in tracking decreases in cognitive performance.

The Behavioral Health and Performance Element also collected data for several ongoing inflight investigations. One study looks at behavioral issues associated with isolation and confinement by analyzing journals kept by the crew during ISS missions. A systematic analysis of different behavioral issues experienced on long-duration missions will allow NASA to design equipment, living spaces, and procedures that allow astronauts to best cope with isolation and long-duration space flight.



The Journals investigation helps NASA design equipment and procedures so astronauts can best cope with isolation during long-duration exploration

A sleep study is examining the effects of space flight and ambient light exposure on the sleep-wake cycles of the crew members on both the Shuttle and International Space Station. A wrist-worn Actiwatch (small, light-weight recorder of activity patterns and light exposure) records the activity of the crew and the ambient light they experience. In addition, crews maintain sleep logs to record subjective information about the amount and quality of their sleep. This work will help define lighting and other habitability requirements, sleep-shifting methods, and workload plans for future exploration missions and determine if further countermeasures to enhance sleep quality are needed.

National Space Biomedical Research Institute

The National Space Biomedical Research Institute (NSBRI) contributes substantially to NASA's exploration objectives involving completion of the International Space Station, a return to the moon, and exploration of Mars. Founded in 1997 through a NASA competition, the Institute is a non-profit organization dedicated to advancing biomedical research to ensure a safe and productive long-term human presence in space.

Consortium Members

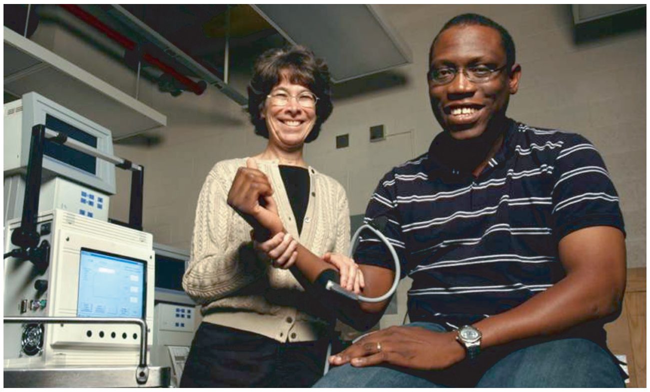
- Baylor College of Medicine (lead institute)
- Brookhaven National Laboratory
- Harvard Medical School
- The Johns Hopkins University
- Massachusetts Institute of Technology
- Morehouse School of Medicine
- Mount Sinai School of Medicine
- Rice University
- Texas A&M University

By developing new approaches and countermeasures to prevent, minimize, and reverse risks to health, the Institute is an essential partner with NASA. With funded projects across the U.S., the research results and medical technologies developed also have impact for similar conditions experienced on Earth, such as osteoporosis, muscle wasting, shift-related sleep disturbances, balance disorders, and cardiovascular and immune system problems. The NSBRI also supports a robust education and outreach program encompassing a variety of activities from kindergarten to independent investigator, including curriculum and teacher professional development, undergraduate and graduate education, and postdoctoral fellowships. To read more about the institute visit the website at **http://www.nsbri.org/**.

Major Accomplishments

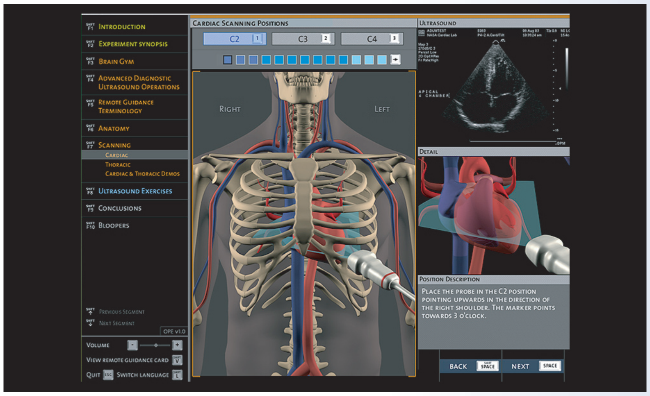
The NSBRI's research program aids NASA by accelerating the transfer of findings from the laboratory to spaceflight and clinical applications. The product-oriented approach to research and development is leading to a number of operationally-relevant countermeasures and technologies ready for testing and evaluation aboard the International Space Station and in medical settings. Collaborations and revolutionary research advances are leading to substantial benefits for both the space program and the public. Projects typically involve successful partnerships among academia, industry, and government entities to achieve a deliverable for NASA and for commercial or medical use.

Trauma and acute medical problems, along with loss of muscle strength and endurance, are serious risks facing astronauts on long missions. NSBRI researchers at the University of Massachusetts Medical School are developing a small, lightweight medical monitor to assess blood and tissue health without using needles. Measurements are made through a near infrared spectroscopic sensor placed directly on the skin. The research group expanded this technology to include new measurement parameters and to provide accurate readings not impacted by body fat or skin color.



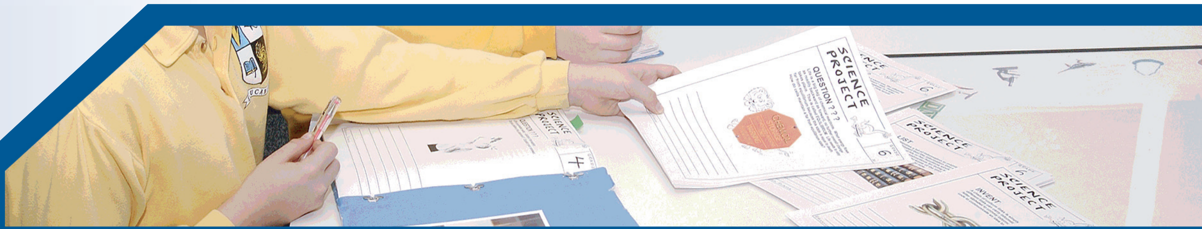
NSBRI investigators are developing a sensor system that will measure blood and tissue chemistry with no need for blood draws or incisions

Diagnosis and management of health problems in space can be difficult due to limited medical capabilities. The NSBRI developed an ultrasound training program to give non-physician astronauts the tools to assess injuries using real-time remote assistance from medical experts. It normally takes 200 hours to learn to operate ultrasound, but this training method cut the time to 2 to 3 hours a year. The experiments and medical tasks completed show the ability of a non-expert to perform ultrasound that can be used to image vital organs and rule out traumatic injury.



The NSBRI-funded ultrasound training program instructs a trainee on correct cardiac scanning position

In another application of ultrasound, NSBRI researchers published the results of the first experiment using ultrasound to seal punctured lungs. A device that uses high-intensity focused ultrasound rays can be applied noninvasively to seal punctured lungs and stop bleeding and air leaks. The bloodless surgery focuses ultrasound beams inside the body on the patient's lungs much like the process of focusing sunlight with a magnifying glass. The rays create a tiny hot spot the size of a grain of rice. The blood cells are heated until they form a seal. The tissue around the spot being treated does not get hot as it would with a laser beam. Tests showed that the procedure sealed leaks in one or two minutes. More than 95% of 70 incisions were stable after 2 minutes of treatment. Results were recently published in the Journal of Trauma.



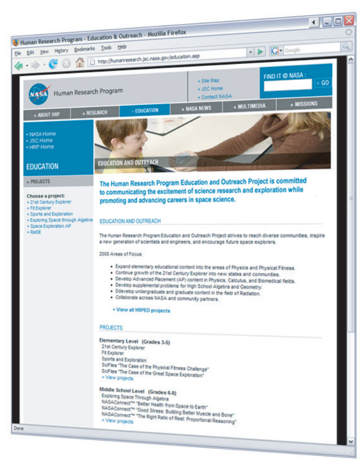
Education and Outreach

The Education and Outreach Project is a multifaceted effort aimed at communicating the excitement of space science research to the Nation. The project targets the entire spectrum of educational levels, providing informational modules for elementary school levels and spaceflight physiology programs at the university level. The projects and products developed by the education and outreach teams focus on the user community, including the public, policymakers, and the media. Project personnel have provided a number of diverse media programs, presentations, and conference exhibits to facilitate understanding of NASA sponsored life sciences research.

Major Accomplishments

The NASA Space Physiology course at the University of Texas, Medical Branch in Galveston, Texas concluded in late spring. In its fifth year, this course was offered as a 2-hour credit elective course to Ph.D. candidates in the Graduate School of Biological Sciences and to Aerospace Medicine residents in the Preventative Medicine and Community Health Program. Four registered students and one auditing student attended 15 lectures by 12 NASA lecturers who represented various disciplines within Space Life Sciences Directorate at Johnson Space Center.

Human Research Program Education and Outreach completed three Stability Flight Experiment final projects using the Digital Learning Network at NASA. Over 180 students from Shady Grove Elementary School in Ambler, PA, Langston Magnet Elementary School in Hot Springs, AR, and Velasco Elementary in Freeport, TX connected to the researchers from the Nutritional Biochemistry Laboratory. Teams from each school researched, built, and designed stability experiments to model the stability flight kits flown on-orbit. Students presented findings of the research conducted, items included in their stability kit, the rationale for including those items, and the nutritional value of the food items in the kit.



Education and Outreach public website

In addition, NASA's partner the NSBRI had a very successful year. The Institute's education and outreach team was awarded a prestigious Stellar Award by the Rotary National Award for Space Achievement Foundation in April 2007. The award was given for "performance as a nationally recognized, top-tier program that is pioneering new models for exemplary teaching and public outreach in support of the Vision for Space Exploration."

The National Space Biomedical Research Institute targets a wide range of educational levels with specific projects aimed at the precollege population:

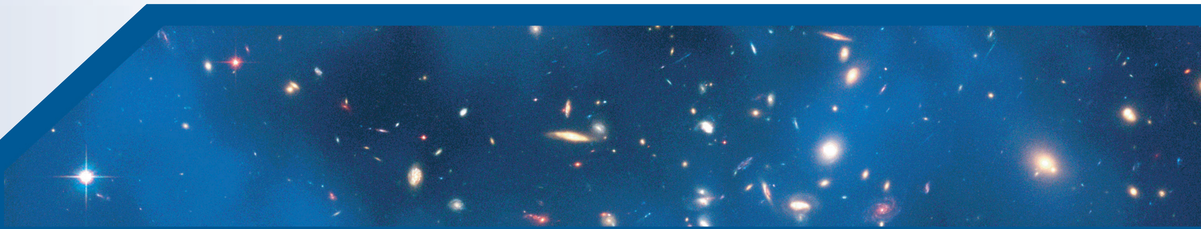
- More than 1,000 teachers participated in NSBRI-sponsored professional development activities
- Nearly 50,000 students were impacted by NSBRI science education materials and laboratory activities
- Thousands of teachers accessed NSBRI-developed web-based resources and online professional development materials
- Partnerships with Challenger Learning Centers and other museums across the United States impacted large numbers of students and families in informal science settings

In the undergraduate and graduate student projects:

- The Summer Internship Program received 75 applications with 12 students selected for 10 to 15 week placements with space life sciences projects at NASA Johnson Space Center
- NSBRI was represented at the National Science Teachers Association Conference in St. Louis, Missouri. Three hundred copies of each of the NSBRI teacher activity guides (Food and Fitness, Sleep and Daily Rhythms, and Muscles and Bones) were distributed to interested educators. An additional 228 teachers requested that NSBRI educational materials be mailed to their home or school

Participants in NSBRI's graduate education and postdoctoral projects:

- Graduate Education Program in Space Life Sciences completed its first year of operation
- A web-based lecture series was launched, wherein NSBRI Team Leaders developed a web-based presentation featuring the work of the Team. This effort promotes a deeper understanding of NSBRI's mission and ongoing research activities by creating web-based learning resources related to all NSBRI research areas. These resources also will be made available to graduate and postdoctoral students and interested faculty and teachers worldwide
- The Postdoctoral Fellowship Program completed its third year of operation. The first set of Fellows from the program all pursued career paths in academia



Future Plans for the Human Research Program

As the Human Research Program celebrates 2 years of operations, a major milestone will be the Program Implementation Review. This review, planned for July 2008, is an independent assessment of the progress of the program. Reviewers will evaluate the quality of the program, the alignment with the objectives for exploration, and the efficacy of the defined processes. In preparation for this review, the HRP has an aggressive schedule to complete numerous reviews of projects, processes, and documents.

Early in 2008, the Institute of Medicine will review the science goals and the risks for human exploration. Discipline teams are developing the HRP Evidence Book that compiles results of research, studies, and other work regarding the body of evidence that NASA has related to risks to human health for exploration missions. The Evidence Book organizes the data used to analyze human exploration risks in a reviewable form for the Institute of Medicine.

The HRP is on schedule to release two new 2-step NASA Research Announcements in early February for space radiation and late July for all other areas of HRP, in concert with the National Space Biomedical Research Institute's research announcement releases.

During the February Human Research Program Investigators' Workshop, the Program will assess the alliances that need to be developed or strengthened during 2008. This will be the first opportunity to communicate the HRP direction and realignment of investigations along the Risk to Gap to Activity paradigm.

The Element and Project Research Plans that are not already complete will be baselined in 2008. The HRP will conduct an internal review in preparation for Standing Review Panels that will be established in 2009 to assess the portfolio and approach defined in the plans for relevancy to the program. For example, do the plans address the gaps and risks adequately and appropriately? Has an appropriate level of review been completed for the task? Is the appropriate approach (directed research study, open competition) or venue (laboratory, analog or space flight environment) selected to accomplish the goal?

In 2008, the HRP will strengthen integration and communication with the Constellation Program and Medical Operations. The HRP will establish methods for measuring progress in assessing risks, communicating evidence based risk recommendations and transitioning knowledge into medical practice and vehicle or suit design requirements.

The Human Research Program will continue to define the challenges that humans will face during exploration missions and to mitigate the risks associated with those challenges. The Program has formed a solid basis for accomplishing this goal and during 2008 and beyond will implement the planning. The Program will continue to build on the knowledge obtained to date to develop results for tomorrow.

How to contact us:

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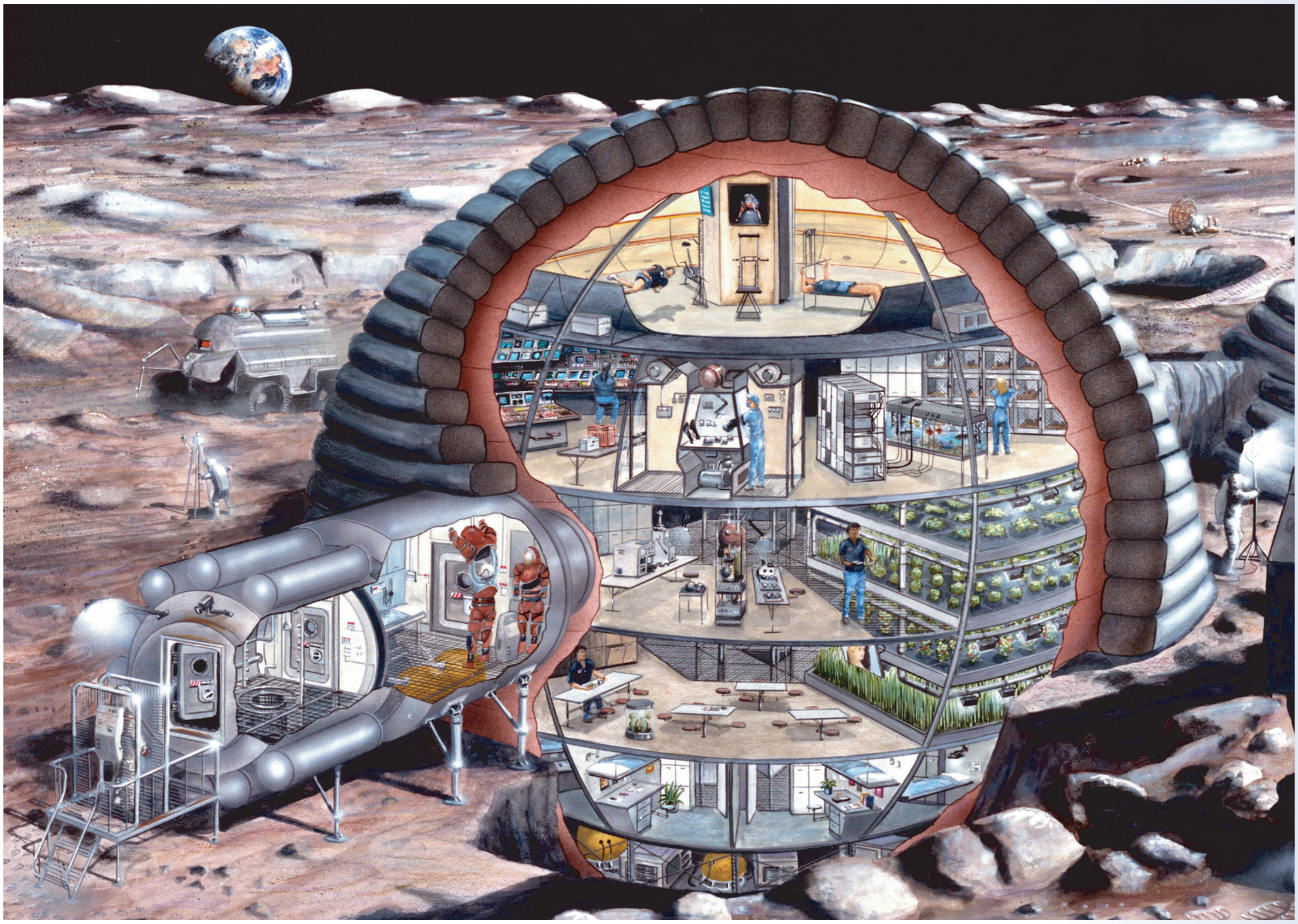
NASA Johnson Space Center
Houston, TX 77058

http://humanresearch.jsc.nasa.gov



Back: An artist's rendering representing a concept of possible activities during future space exploration missions. It depicts remote operations with a pressurized rover.

2007 Human Research Program Annual Report

National Aeronautics and Space Administration

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